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ORIGINAL ARTICLES.

I.—The Earliest Engraved Geological Maps of England and Wales.

By Professor J. W. Judd, C.B., LL.D., F.R.S., V.P.G.S., etc.

IN a previous article,[1] a sketch has been given of what is known concerning the origin and history of the early manuscript maps of William Smith. I have shown that concerning these maps, though they were not *published*, in the technical sense of that term, there exists a satisfactory body of external evidence with regard to the period of their preparation, while they furnish in themselves abundant proofs that they must have been constructed at the dates inscribed upon them. These facts have been so generally recognized that—since the clear statements on the question which have been made by Fitton, Farey, Sedgwick, and Phillips—no one has ever thought of either questioning the antiquity of the maps or denying to William Smith the honour of being the first to construct a true geological map of England and Wales.

But I find that, even with regard to the later maps and sections of William Smith, which were actually engraved and published, there still exists a certain amount of uncertainty. Maps have been publicly ascribed to Smith, with the preparation of which he certainly had nothing to do; while, on the other hand, some of the most important works issued by him have altogether failed to attract the attention which they deserve.

Immediately after the preparation of the Manuscript Map of England and Wales in 1801, the question of its publication, on a larger scale, was seriously taken in hand by Smith and his friends. A prospectus dated Mitford, near Bath, June 1st, 1801, was prepared by William Smith, and extensively circulated by Debrett of Piccadilly (opposite to Burlington House), asking for subscribers to a work that was to be entitled "Accurate Delineations and Descriptions of the Natural Order of the various Strata that are found in different parts of England and Wales, with Practical Observations thereon." The author promised that this work should contain "a correct map of the strata, describing the general course

[1] Geological Magazine, n.s., Dec. IV, Vol. IV (1897), p. 439.

and width of each stratum on the surface, accompanied by a general section, showing their proportion, dip, and direction; the map and sections, to make them more striking and just representations of nature, will be all given in the proper colours." Smith's friend Richardson urged that a Latin edition of the book should be issued with the English one, and it is certain that if this had been done, all possibility of contesting Smith's claim to priority would have been destroyed.

Unfortunately, however, the failure of the publisher Debrett, and the limited means and numerous business avocations of William Smith, prevented the realization of these projects. Thanks, however, to the splendid loyalty of Smith's numerous friends—especially Richardson, Townsend, and Farey—there exists such a body of evidence concerning Smith's discoveries and teaching, all published between the years 1801 and 1815, that no impartial judge can for one moment hesitate in assigning to Smith that priority so strenuously claimed for him by Fitton, Farey, Sedgwick, and Phillips.

Nor can it be justly asserted that the treatment of Smith by his contemporaries was other than generous and forbearing. In 1802 prizes of fifty guineas were offered by the Society of Arts for "mineralogical maps of either England, Scotland, or Ireland, on a scale of not less than 15 miles to the inch," and the offer was renewed year by year down to 1814, when the prize for the English Map was claimed by and awarded to William Smith. As Phillips remarked: "At this moment, any map, however crude and incorrect, professing to be a mineralogical map of a part of the British Islands, would have been a source of lasting reputation to its editor; any account of the principal facts then ascertained near Bath would have been welcomed with admiration. Had Mr. Smith been exposed to this ungenerous rivalry, he must have sunk under the grief and vexation of being anticipated in his map by some inferior compilation, and in his other labours by notices which, in consequence of his wandering habits and laborious profession, it would have been more easy for others than himself to have drawn up. But nothing of this kind happened."

That a knowledge of William Smith's ideas and discoveries had by this time become very widely diffused, not only in this country, but all over Europe, and even in America, there is abundant evidence. Manuscript copies of his original table of strata with their fossils had been widely circulated, and every facility had been given to those interested in the subject to make transcripts of the maps which were so freely exhibited by their author. At agricultural meetings of all kinds Smith was a constant attendant, exhibiting and lending his maps for inspection; while reports of his explanations of maps and sections not unfrequently found their way into the newspapers. At Trim Street in Bath, in the year 1802, and a little later near Charing Cross, London (Craven Street), a collection of maps and sections, with an illustrative series of fossils, was arranged, and exhibited freely to all who chose to call. This collection of fossils, which

after a fire at Craven Street in 1804 was removed to Buckingham Street, was purchased by the Trustees of the British Museum in 1816. It originally consisted of 2,657 specimens, belonging to 693 species, collected at 263 different British localities; and such portions of it as can be identified have been brought together and arranged according to William Smith's original plan in the British Museum (Natural History) at South Kensington, by the pious care of Dr. Henry Woodward.

It must indeed be confessed that, between the years 1801 and 1815, not only did William Smith seem to act as though he were absolutely careless of his claims to priority as a geological investigator, but it is difficult to conceive how he could have adopted plans more calculated to give rise to controversy as to the validity of those claims.

In 1805 Smith's large and detailed geological map of Somersetshire was completed and publicly exhibited, and a project was started by Sir John Sinclair, the President of the Board of Agriculture, and Mr. Crawshay, a warm friend of Smith, to attach the great geological pioneer to the corps of Engineers then commencing the Ordnance Survey of the country: had this been done, the establishment of the English Geological Survey would have been antedated by no less than thirty years. But this project, as well as attempts made by Sir Joseph Banks and other friends to procure the publication of Smith's map by subscription, were doomed to failure. Smith's wandering life, his unfamiliarity with literary work, and his disinclination to engage in it, no less than the constant attraction of field-research, by which he was continually making additions and corrections in his maps, all conspired to render difficult the publication, in a worthy manner, of the great work which he had produced.

In 1807 Greenough, with the aid of a few mineralogical friends, founded the Geological Society. By that date we are told that the idea of publishing Smith's geological map was so generally recognized as having been abandoned, that, among the undertakings recommended to the infant society as especially worthy of its attention, was that of the compilation of a Geological Map of England and Wales. The idea was warmly espoused by the Society, and the work was entrusted to Greenough, by whom the task was commenced in 1808.

It should always be borne in mind that this work of Greenough, though of great value in itself, was an undertaking of a totally different kind from that of William Smith. Smith was a great original discoverer and creator, and almost every entry on his map was the result of his own personal observation. Greenough, on the other hand, was essentially a clever and an industrious compiler. He received, from the first, valuable assistance from such men as De la Beche, Buddle, Farey, and other geologists; Aiken contributed a geological sketch of Shropshire, and Fryer one of the Lake District; while Buckland and Conybeare both made valuable contributions to the work. Most important of all was the circumstance

that the actual engraving of his map was entrusted to a geologist who is second only to William Smith himself in his contributions to English stratigraphical geology. Thomas Webster, in his letters to Sir Henry Englefield, published in 1815, had shown that he had unravelled many of the complexities of the English Tertiary strata, and laid the foundation of a correct classification of the beds which underlie the Chalk in the South-East of England; and it was to Webster that we owe the actual preparation and engraving of the Greenough Map.

Many years afterwards, Greenough published a Geological Map of India—a country which he had never visited—by bringing together all the scattered observations recorded in journals or existing in manuscript in the Archives of the India House. It would not be correct to speak of Greenough's Map of England and Wales as a mere compilation like his Map of India, for it is evident that in the case of the former map he took much pains in verifying and correcting information upon the ground, as is vouched for by Conybeare and other authorities. On the other hand, Greenough's claim that his map should be regarded as an independent work, when compared with that of William Smith, is one that no geologist who has studied the question can reasonably allow. In saying this we do not for one moment impugn the good faith or question the honesty of Greenough. Owing to the unfortunate procrastination of William Smith in the matter of publication, many of his ideas and discoveries had become public property, even before the commencement of the century, and Greenough may very well have been quite unaware how much of the current information on the succession and distribution of the English strata was directly traceable to the labours of Smith. In 1865, when the Greenough Map had become the property of the Geological Society, and a third and revised edition was being prepared, a Committee of the Society, which included Godwin-Austen, Murchison, Prestwich, and Phillips, deliberately recommended, as the result of their inquiries, that the map should henceforth bear the imprint "*based on the original map of William Smith*"; and every unprejudiced student of the history of geology will agree that the action of the Council in adopting this suggestion was a wise and just one. Apart from his industry and perseverance in Cartography, it must be admitted that the claims of Greenough to be regarded as a pioneer in geological research cannot for one moment be compared with those of William Smith. In the same year that his map appeared, Greenough published his work "A Critical Examination of the First Principles of Geology"; and an inspection of this work will satisfy any geologist that even at that date he held the most uncertain views concerning the use and value of fossils, and, indeed, upon all geological principles that were not included in the creed of the straitest sect of the Wernerians.

In 1812 Greenough laid the first draft of his map before the Council of the Geological Society, and in the same year William Smith at last found a publisher for his great work in the enterprising John Cary.

While constructing the small manuscript geological map of England and Wales, William Smith became convinced, as he tells us, that "the intricacies in the marginal edges" (of the strata) "were such that I found to mark point by point, as the facts were ascertained, was the only way in which I could proceed safely. My experience in what I had done upon the Somersetshire Map was sufficient to convince me of this, and that to make a map of the strata on a scale as large as Cary's England (five miles to an inch) with sufficient accuracy, much of it should first be drawn on a larger scale."

The delay in publishing the work certainly resulted in the Map of England and Wales being much fuller in detail than it would have been if issued in 1801. Instead of the eight colours used in the early map, we find no less than twenty colours employed in the engraved map of 1815; and three other spaces were introduced into the legend, though left uncoloured. We also find separate indications used for collieries, lead-mines, copper-mines, tin-mines, and salt and alum works, while the distribution of the great areas of granite and other igneous rocks were fairly indicated. One very important feature of the map was the inclusion of a section from Snowdon to the south-east of England, in which the superposition and dip of the strata and the formation of escarpments and intervening vales by the agency of denudation are clearly illustrated.

The chief defects in the famous map of William Smith, which was at last published on August 1st, 1815, were as follows:—The representation of the Tertiaries was very inadequate, no indication of the Crags being given, the Isle of Wight Tertiaries, the Bagshot Beds of Southern England, and the Boulder-clays of East Anglia being all confounded together, and the relations of these to the London Clay being left obscure. The Wealden area was altogether unsatisfactorily treated, the argillaceous strata being coloured as "Oaktree Clay" and the arenaceous as ironsand (Lower Greensand, etc.). Lastly, the Jurassic estuarine strata of North Yorkshire were confounded with the "carstone and ironstone" of the South-East of England. On the other hand, it is interesting to note that Smith had already learned at this early date the existence of strata lying between the Old Red Sandstone and the slaty rocks of Wales and Cumberland. These have a tablet assigned to them in his legend with the description "various alternations of hardstone, limestone, and slate," though the information he possessed was not sufficient to enable him to extend proper colours for them to the map. This is probably the earliest notice of the strata afterwards made so famous by the researches of Murchison and his coadjutors.

The period following the issue of his great geological map was one of much activity to William Smith. In the year which witnessed the publication of the map (1815) he issued "A Geological Table of British Organized Fossils which identify the Courses and Continuity of the Strata"; and in the following year he prepared the first part of his "Strata identified by Organized Fossils," only four parts of which out of the seven contemplated ever saw the light. In 1817 Smith published an enlarged section from Snowdon to London.

This very important work, which was issued by Cary on July 15, 1817, illustrates in a remarkable manner the clearness of Smith's views regarding both the underground structure of the country and the relations of the forms of the surface produced by denudation to that structure.

In May, 1819, there appeared seven other geological sections by William Smith, illustrating the structure of various parts of England, viz.: (1) From London to Brighton through Lewes; (2) through Dorsetshire and Somersetshire to Taunton; (3) through Hampshire and Wiltshire to Bath; (4) through Norfolk (Yarmouth to Lynn); (5) through Suffolk to Ely; (6) through Essex and Hertfordshire; and (7) between London and Cambridge. In all these sections the relations of the strata with the forms and altitudes of the hills are well illustrated, the only points open to serious criticism being the representation of the relations of the London Clay to the strata above and below it, and the nature and succession of the Wealden beds.

In this same year, 1819, William Smith commenced the publication of his "New Geological Atlas of England and Wales," a work which, like so many of his undertakings, was unfortunately left unfinished. Two parts of this Atlas appeared in the year named: the first, containing Norfolk, Kent, Wilts, and Sussex, being dated January 1st; and the second, containing Gloucester, Berks, Surrey, and Suffolk, bearing the date of September 1st. In fulness of detail these county maps are far superior to the corresponding portions of the map of 1815, and they exhibit in not a few cases evidences of great advances in Smith's knowledge.

It was on November 1st of the same year that Greenough's Geological Map of England and Wales made its appearance. A glance at this map will show that in many respects it exhibits considerable advances in geological cartography as compared with Smith's map of 1815, or even with the later county maps. But it must be remembered, as already pointed out, that the work was really based on that of Smith, that for the Tertiary formations and the strata below the Chalk Greenough had the invaluable collaboration of Thomas Webster (who engraved the map), and that for all the other parts of the country many of the Fellows of the Geological Society supplied numerous very valuable contributions.

On February 1st, 1820, there appeared the third part of Smith's Atlas, containing the Maps of Oxford, Bucks, Bedford, and Essex; and in the same year Cary, who published all Smith's maps, issued a "New Geological Map of England and Wales, reduced from Smith's Large Map, for those commencing the Study of Geology." This map does not differ in any essential feature from the map of 1815, from which it was reduced. The scale of the map is nearly the same as that of a reduction of the Greenough Map, published in 1826 by J. Gardner; and this latter map has been frequently though erroneously ascribed to William Smith.

In the following year (1821) appeared the fourth part of the

Atlas. It is a very important work, namely, the Geology of the County of York, in four sheets. This is one of the finest of Smith's works. It is full of admirably worked out details. In the West Riding, the outcrops of the chief of the grit-beds are represented on the map with their relations to the coal-seams, and a fine vertical section of them is given; and in the north-east of the county, Smith clearly defines the estuarine strata of the Lower Oolites as follows: "Sand Rock and Grit Freestone of the Moors, lying over the Alum Shale" (Upper Lias), "and, in Scarborough Castle Hill, under the Oolite or Calcareous Freestone. A thin coal in the cliffs is worked on the Moors at Danby and other places." In this work we see the fruits of Smith's residence at Scarborough, which commenced in the year 1820.

The maps of Part V of the Atlas (Leicester, Nottingham, Huntingdon, and Rutland) were printed in 1821, but the part, according to Phillips, did not make its appearance till 1822. Two years later Part VI, with the Maps of Northumberland, Cumberland, Durham, and Westmoreland, was issued, and this was the end of this very important undertaking, though Phillips informs us that "other parts to complete this work were left in a state of forwardness." With the exception of a little "Synopsis of Geological Phenomena," a single folio sheet printed at Oxford in 1832 at the Meeting of the British Association, the Geological Atlas of England and Wales was the last of William Smith's published works. It is perhaps not generally known that the plates of Smith's Atlas seem to have been acquired from Cary by the well-known map-publishers Messrs. Crutchley, and the sixpenny County Maps for many years issued by that firm contain the lines and legends of William Smith's maps.

In attempting to solve various questions that have arisen in connection with the history of these early geological maps of the British Islands, I have received much valuable assistance from Mr. F. W. Rudler, F.G.S., the Curator and Librarian of the Jermyn Street Museum. And to the same gentleman the Department of Science and Art is indebted for the gift of a number of maps which have proved to be of great value in making more complete the series exhibited in the Science Museum.

II.—On the Flame-Reaction of Potassium in Silicates.

By Grenville A. J. Cole, M.R.I.A., F.G.S.,
Professor of Geology in the Royal College of Science for Ireland.

WHEN recently examining a series of igneous rocks for the Geological Survey of the United Kingdom, I required a ready method for the determination of potassium in the felspars, whether they occurred as porphyritic crystals or as microlites in the groundmass. The ordinary flame-reaction has always been recognized as unsatisfactory in the presence of sodium, and the use of blue glass has been long recommended, of a sufficient thickness to cut off a sodium flame, the potassium flame then coming through alone.

The blue glass usually supplied with blowpipe-cabinets is far too thin, and any strong sodium flame will appear through it as a violet one. On using blue glass 5 mm. thick, all but the strongest light of an intense sodium flame is cut off, and the column or band of flame that does reach the eye appears blue and not violet. On securing, after experiment, a blue glass, or combination of glasses, which gives only this effect, potassium may be safely looked for, and will readily be recognized, even alongside the blue flame due to the presence of an unusual proportion of sodium.

Lithium, it may be observed, is cut off by a much less thickness of blue glass, and can generally, as in lepidolite and spodumene, be recognized by the eye alone, when the assay is held in the very outermost sheath of the Bunsen flame, or barely touching the flame at all.

The difficulty, however, in the case of potassium is that the flame is often so feeble that some doubt exists as to its occurrence when viewed through 5 mm. of blue glass. Hence intensification has been sought, in the case of silicates, by mixing the assay with powdered gypsum, a method recommended by Bunsen. On thorough heating, even 3 or 4 per cent. of potash reveals itself in this manner; and Professor Szabó[1] was confident that he could detect even 1 per cent.

The great value of Szabó's results to geologists is their quantitative character; but his determinations of potassium involve the dipping of the assay into powdered gypsum, instead of its complete powdering together with the gypsum. The latter method I have found to be far more certain; but it is obviously impossible to pick up again on the platinum loop, after powdering, the whole of the assay selected, or a known bulk of it. Hence even the results with gypsum have given little satisfaction in practice.

It seemed, however, that decomposition of the assay in a bead of sodium carbonate might get rid of the difficulties surrounding the reaction. We should always have the satisfaction of knowing that what we saw could not be due to sodium, for this flame would be eliminated by testing our blue glass in each case on the bead alone. Moreover, the most refractory silicates would be dealt with even more completely than when intimately powdered up with gypsum.

Since the simple support used in testing this reaction, and in all such work in the laboratory of the Royal College of Science for Ireland, was described in the Geological Magazine,[2] it may seem appropriate to furnish the details of this later process here.

The ordinary observations, as arranged by Szabó, may be gone through first, on an assay of the dimensions used by that author. In place of the observation with gypsum, I would venture to substitute the following. In many cases, such as the determination of the presence of potassium in the groundmass of a lava, it may suffice as the only observation to be made.

[1] "Ueber eine neue Methode die Feldspathe zu bestimmen," p. 34; Budapest, 1876.
[2] G. Cole, "A Simple Apparatus for Flame-Reactions": Geol. Mag., 1888, p. 314.

(i) From a crushed and pure sample of the silicate or groundmass, select a bulk of about two cubic millimetres. This is about twice the bulk used in the ordinary Szabó reactions.

(ii) Place the cone on the star-support round the lower part of the Bunsen-burner, the flame rising some 15 cm. above it.

(iii) On the end of the platinum wire make a loop about 2 mm. in outer diameter; dip it into water—all ordinary waters are sufficiently free from potassium—and pick up on it powdered sodium carbonate. Fuse this into a bead covering the loop.

(iv) Examine the flame produced by this bead through 5 mm. of blue glass, and note that the blue column in the flame has no violet fringe.

(v) Remove the bead from the flame, dip it into water, and pick up the selected particle or particles of the assay.

(vi) Fix the wire on the support, so that its loop falls in Szabó's position, in the edge of and enveloped by the flame, and 5 mm. above the top of the cone. Leave it for two minutes, noted by the watch.

(vii) Then examine the resulting flame edgewise, i.e. with the plane of the blue glass upright and parallel to the length of the wire. If potassium is present, a violet flame will be seen, on the inner side of the blue column produced by the intense sodium. The *intensity of colouration* is as important quantitatively as the extent of the flame. This flame is persistent for ten minutes or more, and may thus be examined at leisure.

(viii) In some few cases, a further intensification may be required. Remove the bead, dip it into a drop of strong hydrochloric acid, and insert again in the flame. The flames from the chlorides thus formed rival those produced by the sulphates under the best conditions of the experiment with gypsum.

I find it sufficient to tabulate the results obtained by the method described in paragraph vii under three grades:—

Grade 1 = about 4 per cent. of potash.
„ 2 = „ 8 „ „
„ 3 = „ 12 „ „

I would advise each worker, however, to establish these grades for his own eye and his own blue glass, upon specimens of known and analyzed minerals.

Where only the qualitative result is required, the flame may be viewed from the back, i.e. along the platinum wire, when a violet flame of varied intensity will easily be detected, occupying almost all the region covered by the flame rising from the bead.

As examples of the use of the scale above suggested, the following results may be quoted. The burner used was 9 mm. in inner diameter; the cone was 5 cm. high, and its top was 35 mm. above that of the burner; the flame was 18 cm. high, and 145 mm. above the top of the cone.

Grade less than 1.—Oligoclase, Ytterby. Flame just perceptible in some experiments. Average of six published analyses gives $K_2O = \cdot 62$ per cent.

Albite, Amelia Court House, Virginia. No result. $K_2O = \cdot 43$.
Albite, Zöptau, Moravia. No result.

Grade 1.—Apophyllite, Squire's Hill, near Belfast. K_2O probably = 4 or 5 per cent. Analyses of other apophyllites give 3·10–6·30.
Biotite, Miask. This is a low result, but one analysis gives K_2O as low as 5·61, while the potash in biotite from other localities may sink to less than 1 per cent.

Grade between 1 *and* 2 (1·5).—Elæolite, Brevig. $K_2O = 5 \cdot 17$.
Elæolite, Magnet Cove, Arkansas. $K_2O = 5 \cdot 91$.
Anorthoclase, Pantelleria. K_2O varies from 2·53 to 5·45.
Obsidian, Lipari. $K_2O = 5 \cdot 1$.
Pitchstone, Corriegills. $K_2O = 4 \cdot 7$.
Groundmass of Phonolite of the Schlossberg, Teplitz. The bulk-analysis of the rock has $K_2O = 6 \cdot 57$.
Groundmass of Phonolite of the Schlossberg, Brüx. This is full of small nepheline crystals.

Grade 2.—Muscovite (probably Russian). K_2O probably = 9 or 10 per cent.
Biotite, Burgess, Canada. Intensified to 2·5 by HCl. K_2O probably about 8 per cent.

Grade between 2 *and* 3 (2·5).—Porphyritic Orthoclase (Sanidine) in trachyte of the Drachenfels, near Bonn. Average of five analyses gives $K_2O = 9 \cdot 7$.
Groundmass of Phonolite, Schloss Olbrück, Eifel. Rich in minute leucite crystals. Compare with the figures above given for phonolites rich in nepheline or nosean.

Grade 3.—Microcline, Pike's Peak.
Orthoclase from drusy cavity in granite, Slieve Donard, Mourne Mountains.
Orthoclase (Adularia), Schwarzenstein, Zillerthal.
Leucite. K_2O = about 20 per cent.

Evidently all true orthoclases, with their K_2O = about 13 per cent. (theoretical 17 per cent.), come in grade 3. Soda-orthoclase will give 2·5, and anorthoclase 1·5 or even lower.

Spodumene, with its good lithium flame visible to the naked eye, gives no result through the blue glass used in these experiments.

Lastly, the advantages claimed for the employment of sodium carbonate in place of gypsum are:—(1) The certainty in each case that the sodium flame is clearly differentiated from that of potassium; we have a large quantity of sodium present, and we have eliminated its effects. (2) Complete decomposition of the assay. (3) Security against loss of the assay when picked up on the moistened bead and inserted in the flame. It is quickly fused in and absorbed. (4) Since the operation is always performed in the presence of sodium, there is no need for elaborate cleaning of the wire after each experiment, or for the use of distilled water.

III.—On *Oudenodon* (*Aulacocephalus*) *pithecops* from the *Dicynodon* Beds of East London, Cape Colony.

By H. G. Seeley, F.R.S., Professor of Geology, King's College, London.

THE genus *Oudenodon* of A. G. Bain, 1856, was adopted by Sir Richard Owen, and defined as comprising Anomodont reptiles of the type of *Dicynodon*, but absolutely toothless. Still, they were referred to a family Cryptodontia, under the belief that the teeth were immature and had their development arrested, so that they never descended to the adveolar margin. A transition might easily be made from the caniniform production upward of the alveolar border seen in *Oudenodon* to the small teeth in *Dicynodon dubius* and *D. recurvidens*, which are in contrast to the great lateral ridges formed by the roots of the teeth in most species of the genus. The species *strigiceps* was referred first to *Dicynodon* and then to *Oudenodon*. Owen described eight species, which differ from each other in the elongation of the head, in the form of the preorbital region and its prolongation in front of the nares, in the forms of the orbits of the eyes, and the anterior nares, and in the median postorbital region being either a sharp ridge or a more or less flattened concave channel. These characters might have been used to define genera.

The species fall, more or less easily, into two groups, and this is also true for *Dicynodon*. The same characters differentiate the short-nosed from the long-nosed species of both types, suggesting that the genera based on presence or absence of teeth in this case are artificial. Thus, the short-nosed Oudenodons are almost indistinguishable except as species from the short-nosed Dicynodons; and the long-nosed Oudenodons similarly approximate in skull-shape to the long-nosed forms of *Dicynodon*.

I therefore propose to divide *Oudenodon* into two subgenera.

The short-nosed types, with a wide flattened concave region between the temporal vacuities, the parietal foramen in its middle length, and orbits more or less circular and directed forward and upward, are represented by the species *O. Baini*, *O. raniceps*, and *O. megalops*. They may be indicated by the name Aulacocephalus.

The prognathous species have the orbits more lateral, the parietal foramen just behind the orbits, and a sharp median ridge between the temporal vacuities which may extend along their length or be limited to a part of it. This group is represented by the species *O. magnus*, *O. prognathus*, *O. brevirostris*, and *O. Greyi*, and may be indicated by the name Rhachiocephalus.

In the same way I would divide *Dicynodon* into two subgenera.

The short-nosed species have a broad concave parietal interspace between the outwardly inclined faces of the postfrontal bones, which make the inner borders of the temporal vacuities. The parietal foramen is in the middle of this area. The nares are scarcely seen when the skull is viewed from above, and owing to the shortening of the snout the orbits are directed forward. The species include *D. Baini*, *D. tigriceps*, and presumably *D. testudiceps*, and may be defined by the name Aulacephalodon.

The prognathous type, with a median crest between the temporal vacuities, includes the species *D. lacerticeps*, *D. leoniceps*, *D. pardiceps*, and *D. feliceps*. They are grouped under the name Rhachicephalodon. I have no doubt that one-half of *Oudenodon* with the concave parietal region should be closely associated with the similarly characterized half of *Dicynodon*, and that the half of *Oudenodon* with a parietal ridge should be associated with the Dicynodonts which have the same character. Yet owing to the absence and presence of teeth in the two groups there may be some convenience in keeping the types distinct. In tabular form these species may stand thus:—

Oudenodon.

Aulacocephalus.	*Rhachiocephalus.*
Baini.	magnus.
raniceps.	prognathus.
megalops.	brevirostris.
? strigiceps.	Greyi.

Dicynodon.

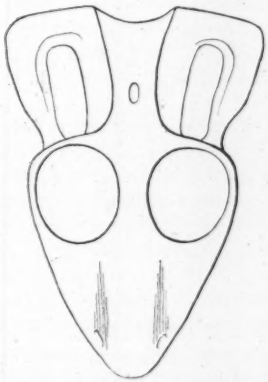
Aulacephalodon.	*Rhachicephalodon.*
Baini.	lacerticeps.
tigriceps.	leoniceps.
testudiceps.	pardiceps.
	feliceps.

Almost all these specimens were obtained from the Graaff Reinet district and the Fort Beaufort district, at the time when Cape Colony was expanding to the east, and Mr. A. G. Bain was engaged in making military roads. The *Aulacephalodon tigriceps* is from the Gonzia River, Kaffraria; and *Aulacocephalus raniceps* from East London. As the strike of the beds is the same from Graaff Reinet to East London, ESE., it is probable that these fossils occur upon a definite geological horizon, above the zone of *Pareiasaurus* and *Tapinocephalus*, and below the zone of *Ptychognathus* (*Lystrosaurus*), near the bottom of the Middle Karroo, in what have been termed the Beaufort Beds.

Many years ago Mr. McKay, of East London, sent to this country a small collection of fossils from the black slaty rocks of the East London district. Professor Huxley in 1868 selected one of these as the type of the genus *Pristerodon*, described in the Geological Magazine for that year, Vol. V, p. 201, Pl. XII.

The collection also included a small *Oudenodon* now catalogued in the British Museum (Natural History) under the number R. 1819, which is distinct from all described species and may be referred to as *Aulacocephalus pithecops*. It is somewhat crushed, and is remarkable for its small size, being only three inches long. It is distinguished by the very large size of its nearly circular orbits, which are placed in the middle length of the head, have a diameter of $\frac{8}{10}$ inch, and approximate closely to each other, so that the frontal interspace between them is narrower than the concave parietal area, which is its hinder prolongation. The species is defined from *O. magnus* by the concave parietal region; from that species and

O. prognathus by wanting the anterior angle to the eye. It is separated from *O. Greyi* by the same characters, as well as by wanting the large anterior nares of that species, and by having the temporal vacuities elongated from front to back. It has a relatively longer nose than *O. megalops*, has not the eyes so far forward as in *O. Baini* or *O. brevirostris*; and the skull is much narrower than in the East London species *O. raniceps* and differs in its proportions, being of thin and delicate build, while *O. raniceps* has the bones relatively strong.



Oudenodon (*Aulacocephalus*) *pithecops*, Seeley, sp. nov.
From the Dicynodont Beds of East London, Cape Colony. Restored from [R. 1819]. Preserved in the Brit. Mus. Nat. Hist. $\frac{1}{3}$ less than natural size.

The skull is depressed, about twice as wide as high, and measured transversely in front of the orbits, it is half as wide as long. The preorbital region forms nearly an equilateral triangle, conical, rounded from above downward and from side to side. Towards the extremity of the snout, on each side there is a longitudinal depression, extending from the orbits forward to the nares. Those openings were small, and at present are obscured with matrix.

The orbits almost suggest the eyes of a lemur in their large circular form; their chief direction is upward and outward. The interspace which divides them is about one-third the diameter of an orbit. The maxillary border extends back as far as the front of the orbit, below which it is notched out and gives place to the malar bar, which contracts a little behind the orbit from above. In side view it is prolonged back parallel to the alveolar margin, uniting in the usual way with the squamosal, and with the vertical bar of the postfrontal bone which descends behind the orbit. The external squamosal element of the zygoma is inclined obliquely outward, and as it extends backward becomes deeper by ascending. Its upper edge is on a level with the base of the orbit in the malar portion at the back of the orbit, but the concave upper outline of the zygoma is on a level with the middle of the orbit, where the arch terminates posteriorly. It is there inclined inward at an angle

of 45°, making the outer hinder angle of the head, which is its widest part.

The upper surface of the skull suggests a sort of cruciform pattern owing to transverse extension outward of the narrow bars of the postfrontal bones which margin the back of the orbits. The parietal region is concave from side to side, margined in length by sharp curved ridges which approximate towards each other in advance of the middle length. In that narrowest part of the parietal the ovate parietal foramen is situate. In those curved lateral ridges run the sutures, which separate the flattened oblique posterior plates of the postfrontal bones from the parietals, till near the squamosal, when the postfrontal descends from the parietal ridge upon the squamosal in the usual way. These oblong postfrontal plates make right angles with the margins of the parietal bones to which they are external; they face towards the zygoma, and posteriorly the postfrontal and zygomatic areas unite in a concavity which emarginates the squamosal bone, and forms the upper lateral outline of the back of the head, on each side of the narrower and shallower concave parietal area between. The temporal vacuities are fully half as long again as wide, and well exposed laterally owing to the low level of the zygoma.

The brain-case appears to be closed by the usual bones which form the vertical occipital plate. They are slightly displaced. The supra-occipital bone is quadrate and single. The interparietal is above it. There is no evidence that the exoccipital bones form the occipital condyle in the way affirmed for *Oudenodon raniceps*, but the exoccipital bones are large. There is no descending quadrate pedicle, but the quadrate bone is short; and the articulation for the mandible appears to be above the level of the occipital condyle, though that structure is not clearly shown.

Seen from the side the superior contour of the head is gently arched from front to back.

It will thus be evident that this species is distinct, and in some details of the articulation for the lower jaw shows characters which are exceptional in the group to which it belongs, though all the short-nosed species have the skull depressed behind and wide from side to side.

IV.—Narrative of a Geological Journey through Russia.

2. Finland (*continued from p.* 15).

By Geo. F. Harris, F.G.S., M.S.G.F., etc.

PROCEEDING in a westerly direction from Tammerfors, we stopped near the station of Siuro to examine some railway cuttings where good sections of gneissose rock and mica-schist, both of Pre-Bothnian age, occur. Macroscopically, the gneissose rock is distinctly and regularly foliated, having small, lenticular, streaks of quartz abundantly disseminated. Locally, however, the section in the field exhibits much contortion; and thin, irregular, veins of quartz, manifestly of secondary origin, are not uncommon.

Under the microscope this gneissose rock presents evidence of great strain and mechanical movement. The quartz, the most abundant mineral present, has been crushed to such an extent as to assume a cataclastic structure, and nearly all the fragments show characteristic mechanical deformation. In addition, the fragments have been arranged in closely packed layers, and where the shearing proved too great for them they have been broken through along these layers; in the undulating cracks thus formed mica occurs in some abundance. It is this structure which renders the rock so distinctly foliate. Felspars are not common in my hand-specimens, and those present are also much broken up. In one micro-slide, however, I find a rather large fragment of a triclinic felspar, much altered by crushing; it is too far gone to enable it to be satisfactorily determined, but presents the general features of microcline. This comparatively large fragment forms the nucleus of a lenticular, augen-like structure, bounded for the most part by mica, interrupted here and there by minutely crushed quartz which invaded the nuclear area. Many of the quartz fragments in the rock exhibit secondary enlargement.

This gneissose rock at Siuro occurs near the junction of mica-schist with an immense *massif* of porphyritic granite.

The next section we examined was in the railway cutting, a little to the west of the station of Suoniemi, where the Pre-Bothnian mica-schist is well exposed. This rock presented no points of special interest. It is reddish-brown in colour, fine-grained, and well foliated. In thin sections, under the microscope, it is found to consist of deformed angular fragments of quartz interspersed amongst orientated minute films of sericite. Large masses of muscovite occur in blocks by the side of the railway, but I did not see them *in sitû*.

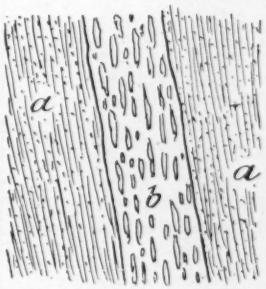


Fig. 3.—Section in a "leptite" quarry, Mauri, Finland.

A railway cutting near Kulovesi showed an indescribable mixture of schist and small veins of granitic rock, on the top of which were a few feet of glacial clay said to be of marine origin, but we saw no fossils. It was an impalpable mud of brownish-green colour.

Walking northwards from this place for a couple of miles, we came to the hamlet of Mauri, and penetrating a wood found a most interesting exposure (Fig. 3) of a rock called by Mr. Sederholm

"leptite." It may be described as a foliated arkose, containing, however, much minute quartz. The rock is salmon-pink in tint A conglomerate of the same material runs through the quarry This has been severely dealt with; the metamorphic action which rendered the sandstone foliated has drawn out the original pebbles into long lens-shaped patches, the major diameters of which, in all cases, are parallel to the folia. Macroscopically there does not appear to be much mica; but micro-examination proves that that mineral is fairly abundant in exceedingly minute flakes. To the naked eye all the mica appears white, or bronze-coloured, though thin sections of the rock demonstrate the existence of a little biotite. Evidently the colourless mica has been produced at the expense of alkali-felspars, and the felspathic constituents as seen in the rock, as it stands at present, have largely become saussuritic. The larger fragments of quartz are very interesting. If I dared use the term in reference to a foliated rock I should say that they act as phenocrysts, for that is exactly what they resemble when one first glances at them under the microscope. They are scattered amongst the exceedingly minute fragments of quartz, altered felspar, and mica, which form a kind of groundmass, out of which they stand conspicuously; and they have been broken up into small fragments by the crushing and shearing to which the rock has been subjected, whilst they present the usual phenomena of cataclastic structure.

The evidence in the field is clearly borne out by micro-examination. I wish we had had more time at this spot, for I feel convinced that much light on an interesting phase of dynamo-metamorphism would be shed by a careful examination of the district. This leptite is foliated enough to place it beyond the pale of an ordinary arkose, and yet not sufficiently to cause it to be regarded as a true schist.

In respect to the relative age of this rock—unfortunately, its junction with the schists near Kulovesi railway station is a fault, and along that line of junction was the only hope of determining its position with reference to the older rocks of the district. At the same time, it is believed that it is younger than the granites of the area, as these latter are brought up against, but do not cut through it. Following the classification detailed in the last article, this leptite and conglomerate are distinctly Pre-Cambrian. But they are, no doubt, much younger than the Pre-Bothnian gneiss.

The next day was devoted to an examination of some rocks on the shores of Lake Näsi (Näsijärvi). We set out in two enormous barges which had been decked over for the occasion, and these were drawn by two very fussy little steam-tugs. It is almost needless to say that nearly all Tammerfors came out to see us off. After a boisterous passage to the other side of the lake, our first *point d'appui* was the locality where "archæan fossils" are found. The landing, and then slipping over many hundred yards of well-polished rock with beautiful glacial striæ, proved rather exciting, which excitement was considerably

accentuated as two or three members fell into pools of water conveniently arranged by Nature in big and deep holes in the immediate vicinity of the "Pre-Cambrian organic remains."

The "archæan fossils" gave rise to an animated discussion. There, on the smooth surface of the phyllades, we saw some circular and ovoid markings outlined by black carbonaceous-looking rings. Nobody seemed to know what they were, and it is to be observed that no one even ventured to give them a generic and specific name "in order that they may hereafter be identified." Vague remarks about "fossil wood" and "impure phyllades" closed the visit to this spot.

Re-embarking, we went to an island in the lake, where a remarkable phenomenon awaited investigation. I have said (p. 15, *ante*) that the Bothnian schists in the neighbourhood of Tammerfors are characterized by the presence of conglomerates on several horizons. As we landed on this island the large pebbles in one of these conglomerates, many of them 3 and 4 inches in diameter, were very conspicuous, and the bed here cropping out must be many yards in thickness. Although indurated, and to a certain extent otherwise metamorphosed, this conglomerate is fresh enough to enable each pebble to be clearly made out, or defined from amongst its neighbours. On the beach the rock is much weathered, and decomposition has set in on the surface of the majority of the pebbles, which are pitted with small holes. Beautiful little faults, having a throw of a foot or so, are seen in several places; they go right through the pebbles, and slickensides is not an uncommon phenomenon.

The structure of this archæan conglomerate exhibits a few points of interest. In addition to the larger stones mentioned there is much grit and fine quartzose sand, the grains of the latter being angulate. The larger pebbles are for the most part fragments of volcanic rocks presenting large phenocrysts of a triclinic felspar. It is difficult to determine the precise nature of these volcanic rocks, but in one of my micro-preparations there is certainly a small pebble of "labrador porphyry." The extinction angles of four large phenocrysts of the felspar in this are + 34, + 36, + 36, + 38, indicating labradorite. These phenocrysts, however, are much altered and have many inclusions. The augite is not very satisfactory and cannot be distinctly identified; I infer its former existence by green decomposition products in small phenocrysts having the approximate appearance of augite.

In addition to these pebbles of volcanic rocks the conglomerate is made up of pieces of rolled phyllade. Mr. Sederholm remarks[1] that all the rocks represented by these pebbles crop out to the south of the conglomerate, and there is, therefore, no reason to suppose they have travelled very far. But he mentions some strangers to the district as occurring therein, viz., "deux variétés de granite ou syénite quartzifère, et une diorite quartzifère."

[1] Guide xiii, "Les Excursions en Finlande," p. 4.

Perhaps the principal point of interest in this Archæan conglomerate is the change which some of the smaller fragments have undergone. These adhere to each other for the most part, but here and there is some well-developed granular quartz which acts as a partial cement. The smaller clastic material consists of pieces of plagioclase, fragments of uralitic augite, of quartz, and perhaps of olivine. There has been a great deal of alteration and secondary development in these fragments and the cement. That might have been surmised from the condition of the augite, as just mentioned, almost completely altered into uralite; whilst the olivine is partially changed to biotite and similar products. Running through this finer clastic material and the cement are roughly parallel lineations of uralite, which is also seen bordering some of the larger pebbles. It is accompanied by occasional minute flakes of biotite.

The rough attempt to produce foliation in this conglomerate and much of the change induced in the pyroxene was doubtless brought about by the same processes which converted the neighbouring volcanic tuffs into uralite schists—for the conglomerates alternate with "beds" of these schists.

Leaving this interesting little island we went across the bay of Hormistonlahti, and landed to make a further examination of the conglomerates and to inspect the uralite schists. The whole of the rock is vertically disposed. These dark-green schists have not been very much altered; their foliation is not conspicuously marked, though distinct enough when closely examined. The volcanic ejectamenta are small, but the fragments, as seen under the microscope, are sufficiently large to enable their basic character to be distinctly made out, and they do not seem to have suffered much in the conversion of the tuff into a metamorphic rock. As will be readily understood, the uralite is for the most part orientated and is the principal assistant in producing the foliate structure. This mineral is most completely formed, and actinolitic needles are not only spread all over it, but project from its sides in characteristic fashion. The needles also have a direction parallel with the folia and impart a semi-fibrous aspect to the mineral.

A brisk walk along the beach enabled us to see that the uralite schist was remarkably uniform in character for long distances; I did not observe any contortion in it. There appeared to be but few exposures inland, a mantle of glacial beds spreading over the surface of the ground and masking the solid beds beneath. But you cannot see far in this part of Finland after you have left the lake-side. The glacial beds give rise to a luxuriant vegetation, and though the trees are not very tall they are sufficiently numerous and close enough together to prevent one from observing much more than arises along the immediate vicinity of the route traversed.

Regaining the barges, we made an earnest attempt to negociate the lake; the little steamers did their best, and in a short time we had covered 12 or 14 miles, in a northerly direction. Landing again some few miles south of Teisko, opposite a grand section in the glacial beds, full of boulders and small fragments of rock,

we climbed a hill to examine an outcrop of granite. We also got out to look at some diorite which has broken its way through the granite. The outcrop of the diorite is very small, not more than a few yards across; but the granite extends for hundreds of miles over this part of Finland. It is the typical Post-Bothnian granite alluded to *ante*, pp. 14, 15. Thin sections show the diorite to be a rather formidable compound; for it is a quartz-mica-hornblende diorite, the whole being much decomposed. There is a considerable quantity of opaque iron disseminated throughout, and my slide shows both black and white micas, though the latter is very rare.

In a little time we arrived at the house of the hospitable proprietress of Teiskola, the most northerly point of our journey; and later on the little tugs took us back down the lake some 20 miles to Tammerfors, sending myriads of sparks from the wood fires flying out of the funnels on the way, the display resembling "fireworks" in the cold night air.

Up early the next morning, we trained to the station of Suinula, a mile and a half from which place we visited an exposure of gneiss. Farther on, along the railway line, near Orihvesi, we came to some large railway cuttings exhibiting the contact between the Tammerfors schists and the porphyroid granite. There seemed to be much difference of opinion as to the precise nature of this junction, which latter, however, was most clearly shown. Our Director, Mr. Sederholm, said that the junction was "mechanical." In the same section is a whiter granite, younger than the schists, which often contains tourmaline.

The porphyritic granite contains many fragments of schist which have been to some extent absorbed by it. The micro-structure of such a fragment shows it to be a typical biotite schist, but having a little white mica; the quartz is in small angular grains and exhibits the usual cataclastic phenomena. Many of the larger quartz crystals have been crushed *in sitû*, the original boundaries of each of these little groups being clearly definable.

Retracing our steps from Orihvesi to Halimaa, we went for a long drive to Kangasala, where we made our first personal acquaintance with åsar. This gives me an opportunity for saying a few words concerning the superficial deposits of Finland. The greater part of the solid rocks of the country are covered by morainic deposits. These are specially well developed, and form one continuous sheet in the north, central, and eastern portions of the land. In the south-central parts this sheet is much interrupted by innumerable lakes, along the shores of which some of the best sections are exposed. The country along the eastern boundary of Finland from near the north of Sweden to the shores of Lake Ladoga is all mapped as "morainic deposits." They are a monotonous series of mixed gravels and sands. On the other hand, in that portion of the country bordering the Gulf of Bothnia and the Gulf of Finland, Glacial and Post-Glacial clays are well developed, and crop out in every little river valley for many miles inland. The greatest expanse of this clay is to the south of Uleåborg, and in the immense tract of

country to the north of Åbo and Helsingfors. Near Uleåborg, also, are extensive deposits of Post-Pliocene sand, smaller patches of which are met with at intervals in the western parts of the country and bordering the Gulf of Bothnia. In the interior of Finland this sand also occurs, and large outcrops are mapped to the north-east of Teisko and near Lake Ladoga, and on towards St. Petersburg; in the southern part of Finland, however, it is but sparingly represented, and it does not appear to occur at all in the northern part of the country above Uleåborg.

Perhaps, the most interesting glacial deposits of Finland are the åsar and stratified terminal moraines, which in some instances stretch uninterruptedly for many miles across the country. We had abundant opportunity of examining these at typical localities, as will presently be described.

Confining attention to the neighbourhood of Tammerfors for the moment, I may remark that the geologists of Finland are of accord that glacial phenomena there are not so simple as in other parts of the Grand Duchy. Messrs. Sederholm and Ramsay state[1] that there are several systems of glacial striæ. The predominating directions are "S. 25° – 30° E. et S. 60° – 65° E. (côté frappé au N.–W.)." To the south of Tammerfors the striations run W.–E., and sometimes N. 65° E. These diverse directions are explained as being formed during the retreat of the ice; but to the north of the town there are striæ running S. 5° E., and belonging without doubt to a more recent system, which is connected with a large terminal moraine found to the north-west of Tammerfors and which, by its configuration and sandy composition, resembles an ås. What is believed to be the oldest system of glacial striæ in the district is in the country to the south of the town where the grooves run N. and S. The morainic gravel throughout is remarkably uniform. The glacial clays in the southern part of Lake Näsi are recognized as marine "*Yoldia*-clays," and there is also a fresh-water deposit.

(*To be continued.*)

V.—The "Irish Elk," *Cervus giganteus*, in the Isle of Man.

By P. M. C. Kermode, Esq.,
Hon. Sec. Isle of Man Natural History and Antiquarian Society.

In September last the Committee appointed by the British Association to "examine the conditions under which remains of the Irish Elk were found in the Isle of Man" commenced excavating at Close-y-garey, near Poortown; but owing to the unusual amount of water, considerable labour and expense were incurred in the preliminary work of draining, and by the 25th September the grant was exhausted.

Our local Committee thereupon took up the work, issuing a circular for subscriptions, the response to which enabled them to carry on the excavations with such success that on the 30th

[1] Guide (op. cit.), p. 8.

September portions of what appeared to be a perfect specimen were disclosed in the undisturbed marl.

The dub, or old marl-pit, in question, lies in a hollow in the glacial drifts, about half a mile south of the Peel Road Railway Station, on the east side of and close to the line. It had about sixty years ago been worked for marl, and the present well-defined banks mark out a rectangular hollow about three feet below the surrounding surface, measuring about fifty yards square.

Across one corner of this a trench was dug to carry off the water, and the operations of the Committee were confined to a triangular area on the west side of the trench, measuring about 15 yards east and west by 30 yards north and south. We excavated all over this space to a depth of nine feet and more. The first four excavations being through ground which had previously been disturbed yielded no definite results, but at one point, about 10 yards from the north bank and 8 yards from the west, a few elk-bones were met with in the disturbed soil. These and some other bones were submitted to Professor Boyd-Dawkins for examination, and he finds among them, belonging to this species, fragments of maxilla, the sixth cervical vertebra, the second lumbar vertebra, and a fragment of a rib.

The last excavation, about the centre of our area, brought us to the undisturbed marl at a depth of about three feet. On testing this I found it to extend to a depth of 10 feet 6 inches at a point about eight yards east of the bank, but four yards nearer to the bank it did not reach a greater depth than eight feet. Between this and the bank it appeared to have been disturbed.

In this bed of white marl, at a depth of about nine feet from the surface, we found the remains of a complete skeleton, lying on its right side, the head towards the bank, the legs drawn up to the body. We considered it necessary to get it out the same day (Saturday), as already many people had been to the place the previous evening, and some one had broken off a piece of the exposed antler. Had time allowed we should have endeavoured to have cleared away the marl from around the bones and had them entirely disclosed and photographed. Time, however, did not allow of this, and as it was very wet we probably should not have succeeded anyhow. Deemster Gill, Mr. Crellin, the Rev. S. N. Harrison, and I therefore took very careful note of the position of the bones as they were gradually uncovered and removed.

So perfect was the skeleton that we had no difficulty in doing so. The bones were nearly all in juxtaposition and in a fair state of preservation. The left antler had fallen back over the lumbar vertebræ; it was rather decayed, the tines had fallen off, and the beam was missing. The other antler had dropped down by the cervical vertebræ, and, except for the beam, was in good preservation, but in lifting it from the marl the tines dropped off. Unfortunately the skull had decayed away and only a portion of the left lower jaw and fragments of the upper jaws remained.

The left antler is the larger; it measures across the palm

15 inches, allowing for a piece of the front edge which has decayed away; the right measures 13 inches. With the tines restored, they are respectively 56½ inches and 53 inches long, and the beam would have been at least 10 inches more. They show six points or tines, besides the brow-tines, which had fallen off, the part where they joined the beam having decayed away.

On laying the bones in position I find that the animal must have been about 18 hands or six feet high at the shoulder. The fact of its having antlers shows it to have been a male; and their size and number of tines, that it was an adult. One of the ribs had been broken, no doubt the result of fighting with another buck in the rutting season, and had healed again. The teeth are in excellent preservation, showing no sign of weakness or decay. The limbs are perfect, all the small bones having, I think, been recovered; the vertebræ also are sound and appear to be all present. The right shoulder-blade, which lay beneath the other, is badly decayed, as are many of the ribs, but I think they can be pretty well restored, and, but for the missing skull and the beams of the antlers, the bones when articulated and mounted will make a perfect skeleton.

Having secured this specimen, we continued our excavations in an easterly direction, but very quickly got through the marl, and again found the soil to have been disturbed as far as our trench.

With regard to the formation in which it was found, the British Association Committee will no doubt have a full report for the meeting at Bristol next September. The result of all the excavations, allowing for the very disturbed state of the ground, shows the following beds:—

	ft.	ins.
A. Disturbed soil and peat, an average of about	3	0
B. In one place a blue clay or silt was observed resting on the white marl.		
C. White marl, containing the elk-remains	6	6
D. Blue marl	1	0
E. Red sand with gravel	0	3
F. Brown clay	0	3
G. Sand and gravel } ? Glacial drift	0	3
H. Clay } ? Glacial drift	4	0

As stated above, the whole surface had been lowered about three feet in digging for marl; the peat had for the most part been removed, and a great deal of the marl also; indeed, we were fortunate in finding this one spot in which the marl itself had not been disturbed.

The finding of detached bones shows that other individuals of this species had perished here, and is consistent with what we were told, namely, that a specimen had been seen when digging for marl, and that the antlers of yet another had been taken out and sold. We were told also that two skulls without antlers had been seen on the east side of our trench.

Samples of the marl and other beds were forwarded to Mr. James Bennie of Edinburgh, for preparation and microscopical examination, and so far as we have heard, the peat appears to be an ordinary lake peat, without anything very distinct about it. The marl contains no

fresh-water shells, but there seems to be a great number of Ostracoda, also some Chara-seeds. The Arctic crustacean *Lepidurus glacialis* and the Arctic willow *Salix herbacea*, which we found in our previous excavations at Ballaugh, seem to be absent from this section. Mr. Clement Reid, of H.M. Geological Survey, has kindly undertaken the determination of the vegetable remains, and we hope therefore to be able to give further information on the subject in our Report to the British Association.

In recording this latest discovery of the remains of the great deer, it is of interest to recall the fact that the first specimen to have been set up, if not, indeed, the first almost perfect skeleton found, is that now at Edinburgh, which was found at Ballaugh in the Isle of Man in 1819. Altogether we have been able to trace remains of about twelve individuals, and possibly more may yet be met with, so that a herd of this noble beast must have existed here after the kingdom of Man became an island. It is more easy to account for its disappearance in so small an area than for its original presence; the best explanation of the latter being that suggested to the writer by Mr. G. W. Lamplugh—that it had crossed over on the ice.

It is somewhat remarkable that no other contemporary remains have been met with, unless we may now except *Equus caballus*, some bones of which we found at Close-y-garey. From their appearance Professor Boyd-Dawkins thinks these may possibly be of the same age: most unfortunately they were only met with where the soil had been disturbed, but they at least suggest grounds for further search, which I hope we may be able to undertake in the near future.

VI.—Notes on the Red-Deer, *Cervus elaphus*, Linn.[1]

By G. Pringle Hughes, Esq.

THE Red-Deer (*Cervus elaphus*), or common stag, is a native of the more temperate regions of Europe, Asia, and North America. In Great Britain it has its freedom limited to the Highlands of Scotland, where, however, it is carefully protected, and affords the *crême de la crême* of British field-sports to the practised rifleman and mountaineer.[2]

In early English History, when the marauding disposition of the people made cattle a precarious property, the wild deer, which depastured the country in large numbers, afforded the staple article of food. Large hunting parties were collected, and as many as 1,000 stags are recorded as having been taken at one of these gatherings.[3]

The true stag and deer are at once distinguished by the presence of deciduous branching antlers in the male, the female being in nearly

[1] Read before the British Association, Toronto, in Section D (Zoology), 1897.

[2] The shooting of some of the deer forests, of from 25,000 to 35,000 acres, is let for between £3,000 and £4,000 per annum.

[3] The ballad of Chevy Chase records such a wholesale slaughter, though the history of field-sports relieves the statement of any suspicion of poetic license.

all cases destitute of such weapons. These appendages vary much in character, being cylindrical or rounded in some species, and flattened and palmate in others. They are bony outgrowths from the frontal bones of the cranium, and, being developed periodically,[1] have an important physiological significance. An extraordinary supply of blood seems to be provided for these bony outgrowths at the spring of the year, and the vessels surrounding the frontal eminences enlarge. This increased vascular action results in the secretion of formative bony matter, producing a swelling or budding at the summit of the frontal bones, at the spot where the horns of the previous season had separated. In the early condition the horn is soft and yielding, and it is protected only by a highly vascular periosteum and delicate integument, the cuticular portion of the latter being represented by various fine hairs, closely arranged. From this circumstance the skin is termed "the velvet." As development goes on, a progressive consolidation is effected; the ossification proceeds from the centre to the circumference, and a medullary cavity is ultimately produced. While this is taking place a corresponding change is observed at the surface. The periosteal veins acquire a great size, and by their presence occasion the formation of grooves on the subjacent bone. At the same time osseous tubercles, of ivory hardness, appear at the base of the stem. These coalesce by degrees, enclosing within their folds the great superficial vascular trunks, which are gradually closed and cease to flow. The supply of nutriment being thus cut off, the first stage of excoriation is accomplished by the consequent shrivelling up and decay of the periosteal and integumentary envelope. The full growth of the antlers is now terminated, and the animals, being aware of their strength, endeavour to complete the desquamation by rubbing them against any tree or other hard substance that may lie in their path. This action is termed burnishing. After the rutting season the antlers are shed, to be again renewed in the ensuing spring; and every year they increase in development, until they attain their maximum growth.[2]

The fossil remains of deer, which have been plentifully found in this country and the North of India, indicate that when unmolested by man and in a wild state they attained a far greater size and probably age than at the present day.

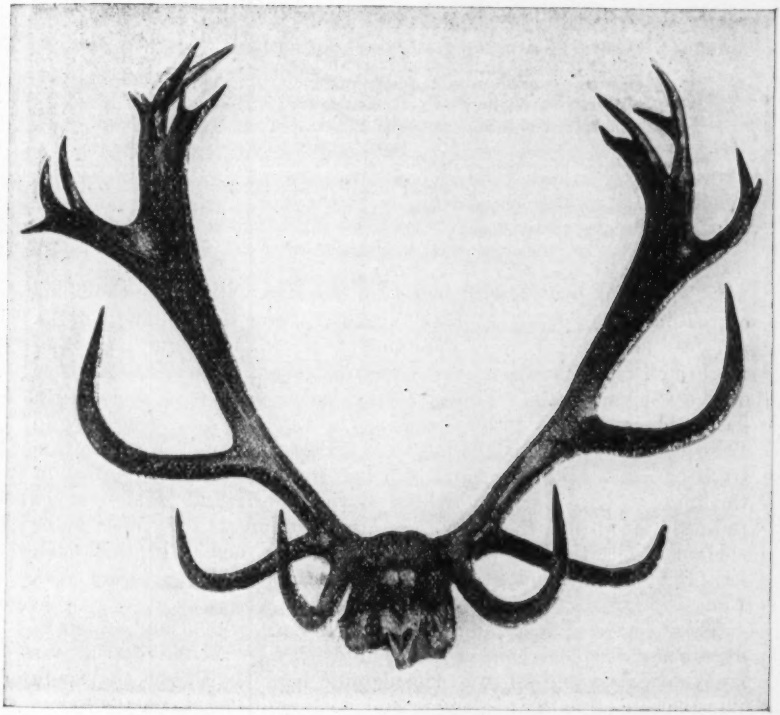
The period of gestation of the hinds extends over 8 months, the young being produced in the month of May. During the winter both sexes collect in vast herds; but in the rutting season the stags

[1] "In the Deer (*Cervidæ*) the antlers consist wholly of bone which grows from the frontals, the periosteum and finely-haired integument, called 'velvet,' coextending therewith during the period of growth; at the end of which the formative envelope loses it vascularity, dries, and is stript off, leaving the bone a hard insensible weapon. After some months' use as such the horns, or more properly 'antlers,' having lost all vascular connection with the skull, and standing in relation thereto as dead appendages, are undermined by the absorbent process and are shed; whereupon the growth of a succeeding pair commences. The shedding of the antlers coincides with that of the hair, and, with the renewal of the same, is annual."—*Owen.*

[2] See Richardson's "Museum of Natural History."

frequently engage in the most desperate encounters, and sometimes the antlers are inextricably fixed by the tines, both animals being left to perish with interlocked weapons.

> "As when two bulls for their fair female fight,
> Their dewlaps gored, their sides all smeared in blood."
>
> VIRGIL: *Æneid*, xii, 715.



Antlers of Red-Deer, *Cervus elaphus*, Linn.

Found by G. P. Hughes, Esq., beneath a peat deposit, Cresswell Bog, eastern base of the Cheviot Hills; and preserved at Middleton Hall, Northumberland.

The specimen of which I submit a photograph is, I have reason to believe, hardly surpassed for size and preservation by any other examples from the peat deposits of Great Britain. The late Earl of Malmesbury, who was for many years tenant of the Auchnacary deer forest in Scotland, and moved among sportsmen of the first rank at home and abroad, saw these antlers, in company with another great sportsman and deerstalker and intimate friend of Sir E. Landseer, the Earl of Tankerville, and was of opinion that only in a few German collections in Hesse Cassel, etc., on the sites of

the vast forests of Franconia and Thuringia, where giant specimens of Mammalia at one time abounded, would their equal be found. I have, therefore, thought it desirable, as I have no descendant of my own, to have this specimen photographed, and a copy sent to some of our national Museums and Societies, in order to have the existence of this fine pair of antlers of *Cervus elaphus* recorded in proper form.

Measurement of the Antlers preserved at Middleton Hall, Wooler, Northumberland.

	ft.	ins.
1. Width from inside to inside of the crowns	2	8
2. Length of the beam to leading crown tine	3	6
3. Width from outside to inside of beam at crown	3	10
4. Circumference of the crowns (left)...	3	5
,, ,, ,, (right)	3	8
5. Length of brow antlers (left)	1	8
,, ,, ,, (right)	1	7
6. Width of skull at stem		6
7. Circumference of stem at base		10
8. Number of points upon the two stems or beams		21

"This set of antlers, with several of less size, with entire skeletons of red-deer measuring 15 hands in height, one foot taller than the red-deer now extant, were exhumed from a lacustrine deposit of marl and peat known as the Cresswell Bog, at the eastern base of the Cheviot Hills. The following is the section of deposits in descending order as given by Mr. G. Tate, F.G.S., Secretary to Berwickshire Naturalists' Club:—(1) Peat, in which are prostrate trees of hazel and birch, and also hazel-nuts: from 2 to 4 feet in thickness. (2) Marl, in which have been found skeletons of red-deer, teeth of the boar, and great numbers of fresh-water shells: 8 feet thick. (3) Blue Clay, a few inches in thickness. (4) Boulder-clay and gravel."—*Transactions of Berwickshire Nat. Club*, 1860.

These facts give a tolerably clear history of the succession of events at this spot. During the Boulder-clay period the district was covered with water up to a considerable height. This period, with its subarctic climate, its glaciers and floating icebergs, passed away, and the present conformation of the British Isles was to a great extent assumed. Where this specimen was found a small lake had been left, in which for ages mollusks lived and bred, for the accumulation of 8 feet of marl, chiefly formed of their shells, indicates a considerable lapse of time. Deer and boar living along its margin, or coming to it for drink, or, I may add, pursued by wolves or Neolithic man, occasionally found a tomb beneath its waters and yielding marl. In the course of time the waters were partly drained off, but the ground being adapted for the growth of mosses, peat was formed over the marl, and trees and bushes growing around were time after time carried by floods and winds into the marshy ground, which they have contributed to increase and solidify.

VII.—The Contact-Rocks of the Great Whin Sill.

By W. Maynard Hutchings, F.G.S.

(*Concluded from the February Number, page* 82.)

IN describing "An Interesting Contact-Rock" (Geol. Mag., March and April, 1895) I gave its analysis, showing:—

Potash	1·25 per cent.
Soda	2·01 ,,

And in this rock also the great relative increase in soda corresponds with the appearance of albite among the new minerals.

But, as stated above, we also have cases of great alteration *without* increase of soda; as, for instance, the two intensely affected shales described from Rowntree Beck and Winch's Bridge, both very rich in alkali, and both showing still a normal excess of potash. And, again, three other specimens of completely altered rocks from near contact give:—

Potash	3·15 per cent.	... 4·24 per cent.	... 3·40 per cent.
Soda	1·20 ,,	... 1·22 ,,	... 0·87 ,,

In these the mica is all regenerated, with chlorite, as described, but there is no sign of any new felspar.

Without burdening this paper with too many figures, I may say that in between these extremes of great alteration of alkali-ratio, and no alteration at all, come determinations giving an intermediate result—soda has increased beyond the normal limits, but still not to the extent of exceeding the potash, as for example:—

Potash	3·55 per cent.	... 1·60 per cent.
Soda	2·20 ,,	... 1·31 ,,

If soda-transfer takes place, we should expect to find evidence of it in the less pure sandstones, as well as in the shales, those with argillaceous interstitial matter being really only diluted shales. I have determined the alkalies in three specimens of altered sandstones, as follows:—

Potash ...	0·25 per cent.	... 0·55 per cent.	... 0·23 per cent.
Soda ...	2·46 ,,	... 2·71 ,,	... 1·12 ,,

Here there is in each case a very decided excess of soda, and the *total* alkali contained is much more than would be expected in consideration of the relatively small amount of original argillaceous material. These determinations, as far as they go, would strongly countenance the idea of transfer of soda in some form, and tend also to show that the sandstones have taken it into combination, and held it, out of proportion to the shaly deposit contained in them.

Tests of some of the limestones have also been made, for the same reason, that where less pure they contain argillaceous material, and should show the alteration of alkali-proportion if it has taken place. Of the following two analyses, A represents a specimen from within a few inches of contact, containing a quantity of garnet and

a good deal of recrystallized silica. B is a rock practically free from minerals other than calcite—only a very few garnets and a little quartz :—

	A.		B.	
Silica	40·90	per cent.	4·60	per cent.
Alumina	5·45	,,	1·95	,,
Ferric Oxide	7·85	,,	0·85	,,
Lime	29·42	,,	51·27	,,
Magnesia	2·17	,,	1·65	,,
Potash	0·28	,,	0·19	,,
Soda	0·74	,,	0·71	,,
Carbonic Acid	10·06	,,	37·50	,,
Water	2·80	,,	2·15	,,
	99·67		100·87	

A portion of B was dissolved slowly in dilute cold hydrochloric acid, the residue filtered and dried, and its alkalies separately determined. It gave :—

Potash	0·35 per cent.
Soda	0·78 ,,

Another limestone, completely recrystallized, and showing grains and small indeterminable crystals of foreign matter, gave :—

Potash	0·26 per cent.
Soda	0·81 ,,

This rock, dissolved in dilute acid, gave a residue which, after filtration and ignition, was 6 per cent. of the original material, and contained :—

Potash	0·58 per cent.
Soda	6·30 ,,

All the above show large excess of soda, but amongst the limestones, also, we find contradictory results. Thus, one altered bed containing augites, etc., gives :—

Potash	2·55 per cent.
Soda	0·62 ,,

Another hand-specimen shows sugary white limestone, together with a layer of brown hornfelsy rock, due to impurer material. The alkali-contents are :—

	White Limestone.	*Brown Layer.*
Potash	0·30 per cent.	5·79 per cent.
Soda	0·07 ,,	1·40 ,,

At my request, Mr. Garwood collected a series of specimens representing the succession of beds downward from the Whin Sill to the basement conglomerate, at Falcon Clints, in Upper Teesdale; as I thought it would be of considerable interest to make alkali-determinations in them, and at the same time examine them microscopically and note the nature and intensity of the alterations. The particulars of the section at this point, as given to me by Mr. Garwood, are as follows :—

Whin Sill, 100 feet thick.		Feet thick.
No. 1.	Limestone, with garnets, etc., where impure; white and sugary where pure, but containing patches of altered shaly matter, sandstone, etc.	24
No. 2.	Shale, weathered	12
No. 3.	Limestone	10
No. 4.	Shale, weathered	6
No. 5.	Limestone	2
No. 6.	Sandy shale	3
No. 7.	Limestone, hard blue, with fossils	8
No. 8.	Flaggy sandstone	10
No. 9.	Shale with nodules	8
No. 10.	Basement conglomerate	2
	Total of sedimentary beds	85

The specimens examined gave results as follows:—

No. 1. This limestone has been described above, so far as concerns the garnet and idocrase-bearing hornfelsy alteration-product, of which an analysis was also given. This analysis showed a large excess of soda. But it was another hand-specimen from the same locality, with both pure limestone and a layer of the hornfelsy material, which gave the figures just quoted, showing potash in large excess over soda.

In this limestone-bed occur patches and lenticular masses of altered sandstone and shale. A specimen of such a sandstone shows, in the sections, that it is rather coarse-grained, with a good deal of interstitial matter of originally argillaceous nature, with fine-grained quartz. This matter is all intensely altered, showing some newly-formed mosaic of quartz and a little felspar, a lot of white mica in beautiful tufts and bunches, and here and there patches of newly-crystallized, glassy-clear groups of well-twinned plagioclase crystals, some of them identifiable as albite. The alkali-contents of the rock are:—

Potash	0·55	per cent.
Soda	2·71	,,

A patch of shale from the same source shows alteration on the usual lines—much of the indefinite new "speckly" product, white mica, chlorite, etc., with "spots" containing more chlorite, less mica, and great aggregations of rutile grains. It contains:—

Potash	4·82	per cent.
Soda	1·48	,,

No. 2. This was a moderately quartzy shale. The quartz is not much affected, but the main mass is greatly altered, chiefly to speckly matter and white mica, the latter often forming clear patches and circular spots of larger, clearer flakes of muscovite, or of muscovite and chlorite. The rock contains:—

Potash	5·36	per cent.
Soda	2·93	,,

No. 3. Limestone, originally impure with argillaceous matter. The bulk of it is not highly altered, not even rendered coarsely

crystalline. But there are many "spots" in the sections, in which, among a good deal of indeterminable matter, some chlorite, etc., are a good many small bits and prismatic crystals of augite. Some augite occurs also outside these spots, but not much. The alkalies are:—

Potash	2·55 per cent.
Soda	0·62 ,,

No. 4. A main mass of fine-grained shale, in which are bedded good large quartz fragments, with numerous flakes of clastic mica, and a good many grains of calcite. The coarser constituents are not altered, but the finer portion has been completely regenerated, giving rise to a small-grained dim sort of mosaic, with a little new mica, and showing here and there larger patches of this and of chlorite. This rock contains:—

Potash	3·55 per cent.
Soda	2·76 ,,

No. 7. This limestone is very much recrystallized, but does not show any distinct new minerals, being only slightly impure:—

Potash	0·26 per cent.
Soda	0·81 ,,

No. 8. A sandstone converted into a quartzite. There was very little interstitial matter, which is now much altered, but details cannot be made out:—

Potash	0·23 per cent.
Soda	1·12 ,,

No. 9. This is the bed described as "an interesting contact-rock," the main characteristics of which were recapitulated above, so that no description need be given here. It was pointed out that the bed varies more or less in composition in different parts, being more or less quartzy, etc. As since I first described it I have made some more alkali-determinations on various specimens, it may be worth while to add them here:—

	per cent.	per cent.	per cent.	per cent.	per cent.
Potash	1·01 ...	0·47 ...	1·60 ...	2·71 ...	0·70
Soda	1·92 ...	1·10	1·31 ...	1·35 ...	1·33

The last is from a sample representing a large number of the "nodules," which were carefully detached from the rock.

We do not know how far from the contact the metamorphism caused by the Whin Sill was capable of extending, but we have here an instance of very great alteration at over 80 feet distance, and may safely say that the action would have continued much further. From published observations on the subject, it does not seem usual for the contact-zone of basic dykes or sheets to be as extensive as this.

The interpretation of the chemical determinations above given does not seem to be an easy or a satisfactory business, owing to their contradictory nature. Many of them show an undoubted access of soda, at least—that conclusion seems to be unavoidable,

unless it can be shown that there are shales, and argillaceous sandstones and limestones, among the Lower Carboniferous beds, and indeed in the particular districts in question, containing soda in some such ratio to potash as is disclosed by these determinations. On the other hand, it is difficult to explain the fact that such soda-rich alteration-products alternate with others, derived apparently from quite similar original rocks, in which, as we saw, soda has not increased, or has increased in a far less degree.

Supposing some compound of soda to pass from the igneous magma into the invaded beds, we can readily explain to ourselves how it could come about that purer limestones show little or no trace of its action. Solutions containing this compound of soda could permeate the limestone, and pass into beds of shale, etc., beyond it, without being in any way permanently taken up and combined with it; and in course of time the limestone would be freed from the merely mechanically held soda; whilst in the complex silicates of the shales would be offered a material with which introduced soda would easily enter into new and permanent combinations. But we cannot very well explain how it is that one bed, or part of a bed, of shale takes up so much more than another. We must leave this, for the present, as one of the many things which we cannot yet make clear.

Looking at those rocks which show a considerable amount of soda-felspars, and carefully observing the part these felspars play in the structure of the rock, and their relationships to the other minerals, it does not seem possible to conclude otherwise than that the soda-increase and formation of these felspars and these structures were all part of the one process of contact-metamorphism and recrystallization of the rock-constituents. No later introduction of soda, by percolation of solutions from the cooled and weathering igneous rock, is at all consonant with what we see. And this is equally true of those beds in which, though we find soda in excess, we cannot detect any felspar with the microscope, and are led to assume that the soda is combined in the abundant new mica developed, in the "speckly" intermediate material, and in other new products.

In this rather indefinite and unsatisfactory position we must, apparently, leave this part of the subject for the present, at all events so far as the Whin Sill is concerned. Having devoted a good deal of time and trouble, both to "looking it up" elsewhere, and to trying to obtain evidence from our most favourable British opportunity of studying it, I make no apology for dealing with it at some length, even though, unfortunately, not conclusively. It touches one of the most important points which still stand first for consideration on our way to an understanding of the true nature and processes of contact-metamorphism.

Incidentally, it is worth pointing out that the series of alkali-determinations given above, supplementing as they do my previous analyses of fireclays and shales, quite definitely dispose of the contention, often put forward, that none of these deposits contain

enough alkali to justify the belief that they could be the early material of true clay-slates, etc.

It is not, however, in this chemical question, nor yet in the mere cataloguing and description of the new minerals produced, that the great interest of the contact-rocks of the Whin Sill is centred. This interest mainly lies in the observation of the nature of the *structures* produced, and the relationships of the minerals to one another; and in the comparison of these structures with those of rocks from great contact-areas round granite intrusions, as well as with those of others, of similar composition, which have been subjected to intense dynamic and deep-thermal conditions, but not, so far as we know, to the action of any intrusions of igneous masses.

When a shale is highly altered by contact with the Whin Sill, we get in most cases, as has been shown, a splitting-up of the complex micaceous mineral of which it largely consists, into a purer, more highly developed white mica, which we may in general designate as muscovite (though to some extent it may consist of paragonite or of an intermediate stage), and into a chloritic mineral. Both the mica and the chlorite crystallize in the rock in all directions, quite irrespective of the stratification-plane in which the original micaceous minerals lie flat. A certain criss-cross structure is at once produced; it commences as soon as the contact-effect is noticeable at all, becomes more and more pronounced in the more highly developed cases, and is often accentuated by the formation of rosettes and sheaves of mica and chlorite. These effects and appearances are all the more striking because they are produced on an original material of such low development. We pass at one step from a rock with no white mica, no chlorite, and no criss-cross structure, to one in which all these things are in full evidence. At granite-contacts we may often see exactly the same products in the altered rocks, but they are then frequently, in that sense, not so striking; because in most cases the rocks acted upon have been in a much higher stage of development; they were not elementary shales, but slates, in which a good deal of formation of mica and chlorite had already taken place. The final result is, however, the same in both cases, and is also the same whether the granite acts on a mere shale or on a slate; we get a pure white mica, and a corresponding separation of chlorite or its equivalent in biotite, cordierite, etc., all crystallized in every direction in the rock.

To make out the minerals and the structures in the Whin Sill rocks we may need high powers, whereas we may see all these things with low powers, or a pocket-lens, in the sections from a granite-contact; but this is a matter of no importance, and is related to nothing beyond the respective bulks of igneous rock concerned, and probably also the greater or lesser depths of the invaded rocks, with corresponding differences of their initial temperatures. The same considerations apply also to the frequent abundance of certain special minerals at granite-contacts, and their absence, or rarity, in the Whin Sill rocks. Leaving aside these conditions of mere size and intensity, the results are strikingly

parallel; and a concurrent examination of a series of rocks from the two sources does not fail to impress one with the idea of how relatively slight and mild a degree of contact-action is required to bring about certain very definite and characteristic effects. I have compared these Whin Sill rocks over and over again with contact-rocks from several localities, and quite recently, whilst once more passing them in review in connection with the putting together of these notes, I have had the opportunity of looking at them side by side with a fine series from Scotland. One can often pick out examples of both, which, barring certain minerals (as e.g. kyanite), are so exactly similar in structure and general nature, that the slide from the granite-contact might be almost imagined to be derived from one from the Whin-contact by some process akin to photographic "enlargement," every detail being reproduced.

But, on the other hand, we may compare these Whin Sill sections with any number of examples of rocks which have suffered the most intense degrees of crushing and shearing, and which have been under enormous depths of cover, without being able to find in these latter any signs of even a *commencement* of the characteristic *structures*, or more than a very moderate amount of the mineralogical development. Such rocks as these, as I have shown in former notes (e.g. GEOL. MAG., July and August, 1896), certainly display a decided degree of advance beyond the clays and shales from which they started. We have the formation of new mica and of chlorite, going along the same chemical and mineralogical lines as in contact-action; but it does not seem to be able to pass beyond relatively moderate limits, giving us a still impure mica. And in the matter of structure the limits are still more restricted. We do not get beyond a felted and wavy mass of mixed mica and chlorite; there is no growth of crystals of mica at all angles and in all directions, no criss-cross structure, no rosettes and sheaves, and no sign anywhere of crystallization of chlorite. Neither do we ever see any trace of the amorphous, or semi-amorphous, and speckly material passing upwards into definite mica, etc., which I have pointed out as so frequently characteristic of rocks which have recrystallized under contact-action. Nor do we see in such rocks any trace of biotite or other special minerals which we know so well in contact-rocks. Yet all these things which we may thus find to be absent from some most ancient sedimentary rocks after they have had every allowance of time, dynamic action, and depth-conditions, we see can be produced in similar materials, almost instantly, as it were, by the action of a relatively insignificant amount of igneous magma intruded among them; the evidence in the special case before us being quite beyond the possibility of confusion or question, as to the fact that these effects are wholly due to the intrusion and to nothing else, and thus much simpler and clearer than often is the case in granite areas.

These observed facts, and the considerations arising out of them, duly weighed, seem to lend a reasonable degree of probability to the conclusion I have suggested on other occasions, viz., that so

far as our present actual *knowledge* goes, there are structures and mineralogical developments which, whenever we see them, even in moderate degrees of evolution, we are not only justified in ascribing to contact-metamorphism, but which we have not an atom of reason or evidence for attributing to any other cause, no other cause having as yet ever been *proved* to produce them; and certainly not dynamic action, as to which we can collect plenty of very clear evidence that it has failed over and over again to bring about even the beginnings of them, under the very circumstances which ought to be most favourable for its doing so.

When we look at this matter quite calmly, it certainly does seem rather strange that the "blessed word" dynamometamorphism has been allowed to exercise such a spell over our minds in directions in which it can hardly be said to have ever made good its pretensions. Here were rocks of sedimentary origin, showing very great and striking mineralogical developments. They also showed beyond question that they had undergone great dynamic action. Therefore the latter was the cause of the former. In how many cases has there been but little better evidence than this to support its all-embracing claims, which were made to explain everything without proper proof! And at the same time we have, all around us, examples of the fact that what dynamic action has been asserted, but not proved, to do, is done not only by every great intrusion of granite or other igneous rock, but by even quite small intrusions also.

Let a great area of sedimentary rocks be altered by the action of igneous masses which we cannot see; then let powerful dynamic action follow, and there we have at once a fine example of the marvellous recrystallization and formations of new minerals which dynamic metamorphism has brought about, shutting our eyes to other cases in which even more intense action, on similar materials, has effected practically nothing of the sort.

If we take simply what we at present *know*, and can prove over and over again, and separate it from what is certainly not at all proved, no matter how strong the *a priori* evidence may sometimes appear, it would seem to be quite reasonable if we were to regard certain microscopic structures of altered sedimentary rocks as probably indicating that the alteration took place under the influence of contact-metamorphism, no matter whether we can actually see the igneous rock concerned in it or not. On a similar line of reasoning from what we know, we might also draw the same inference from the development of certain minerals in such rocks, not only the specially so-called "contact-minerals," but others as well. Thus, the presence of undoubtedly newly-formed biotite in altered shales and slates should point the same way, till we have some evidence that any other process known to us can be proved to have the power of producing it. And it might even not be going outside the safe ground of induction if we were to include very highly developed and individualized muscovite, and certain forms of chlorite, under the same head.

Of these several points, that of *structure* certainly appears to be

the most important, and the safest on which to rely, whenever we find it. But we know that dynamic action may have more or less completely effaced this structure, and in a great number of cases has done so.

We know on what lines this effacement proceeds, and with what sort of new structures it replaces those it has modified or destroyed. It is, however, not uncommon to find that, even in greatly affected "dynamic" areas of this description, the action has not embraced the whole of the rock, and from among rolled-out, sheared, and puckered schists, may come specimens showing, more or less perfectly, the contact-structures which we seem to have good grounds for always recognizing as such.

NOTICES OF MEMOIRS.

Compass Variation affected by Geological Structure in Bucks and Montgomery Counties, Pa.[1] By Benjamin Smith Lyman.

THE Journal of the Franklin Institute, October, 1897, contains an interesting paper by Mr. B. Smith Lyman, formerly State Geologist to Japan, describing a remarkable coincidence between the axis of a set of curves of magnetic variation in Bucks and Montgomery Counties, Pennsylvania, and a great deep-seated fault in the New Red strata below ending westwards in the axis of an anticlinal fold. Both the curves and the fault are shown on an accompanying map. From this paper we extract the following passages:—

The magnetic curves were mapped some years before the beginning of the recent Geological Survey, that for the first time fully proved the peculiar structure; but the curves had no influence whatever in the interpretation of the geology, and the correspondence was not perceived until long after the geological map was printed.

The magnetic map was made about the year 1883, by the Water Department of the city of Philadelphia, for use in its excellent topographical survey of the Perkiomen and neighbouring valleys under Mr. Rudolph Hering. The map records the results of a number of determinations of the magnetic declination made by the Water Department itself and by the Coast Survey and by other observers, and curves of equal declination were drawn for every tenth of a degree. The curves are so extremely at variance with the simple, nearly straight lines of earlier, less detailed maps, as either to show extreme confidence in the accuracy of the observations, or perhaps even to excuse a suspicion of the possible incorrectness of the curves in some way, especially in view of the acknowledged want of precision of some of the observations, and the absence of any obvious topographical or other occasion for such

[1] Reprinted from the Journal of the Franklin Institute, October, 1897. Mining and Metallurgical Section: Inaugural Meeting, held April 28th, 1897.

great irregularity. But the curves are in the main beautifully confirmed and thoroughly vindicated by the underground geology.

The striking feature and dominant peculiarity of the curves is a very strong bend convexly north-eastward near New Hope and Lambertville, on the Delaware; but gradually changing towards the west, so that the curves near Shwenksville and Boyertown point still more sharply south-eastward. The axis of the bend in the curves is, then, itself greatly bent, nearly to a right angle. The Geological Survey of the two counties, begun at the end of 1887, has proved beyond a question the existence of an enormous fault, of about 14,000 feet, in the rock beds, almost precisely on the line of the Delaware River end of that magnetic axis, and following the same course past Doylestown, gradually dying out, and west of that town turning north-westward, passing north of Shwenksville, disappearing there as a fault, but continuing as a sharp anticlinal to the border of the New Red and of Montgomery County, 5 miles north-east of Boyertown.

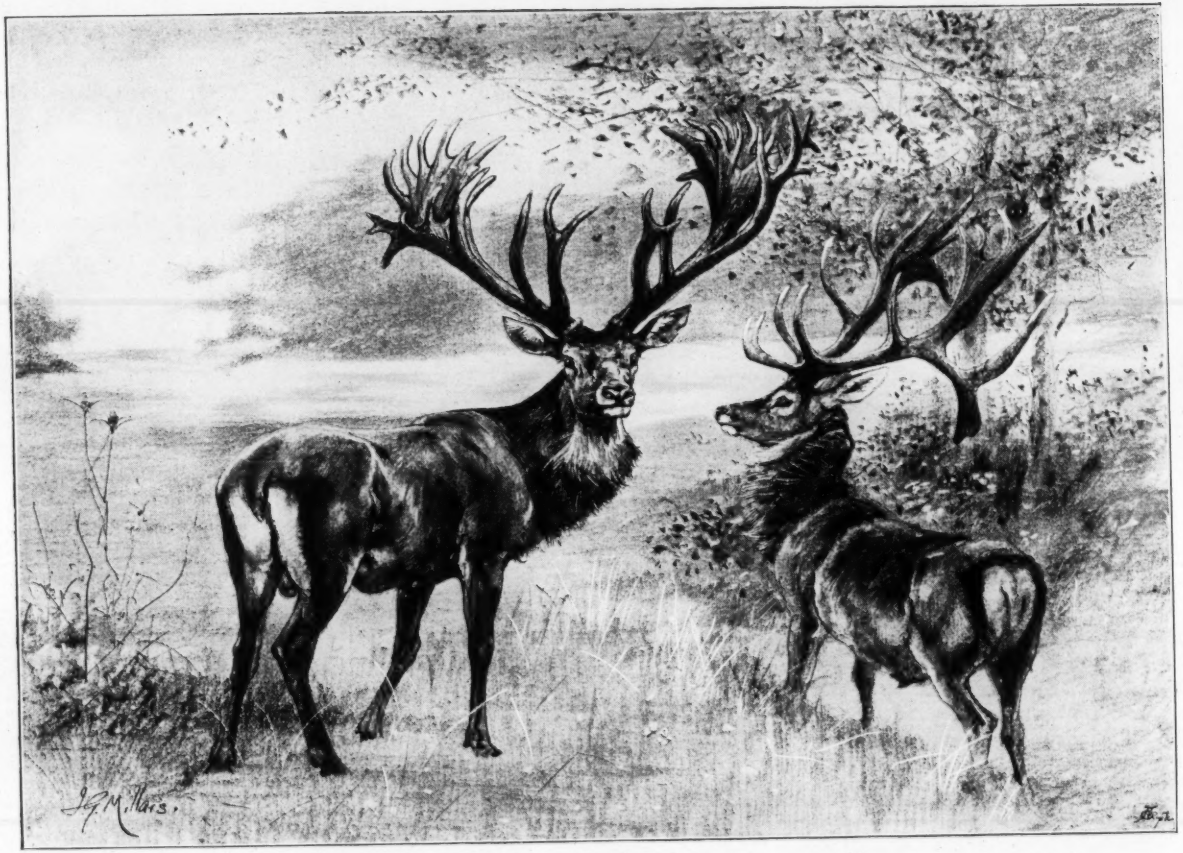
The geological structure of the map of 1893, published by the State Geological Survey, was drawn without the least reference to the magnetic curves, and, indeed, without any knowledge at that time of the slightest correspondence between them and the geology. The geological map gives the direction and amount of the dip at a couple of thousand points, amounting to a complete demonstration of the structure, and to a full proof of the situation and extent of the fault and of the sharp anticlinal into which the fault runs. The topography also given on the same map shows that there is no one strongly-marked ridge following the course of the axis of the magnetic curves. Indeed, there are more decided topographical indications in the way of long, rather high ridges in other directions. Furthermore, the form of the outcropping rock beds, sedimentary or igneous, does not correspond in any degree with the magnetic curves.

Moreover, some light is perhaps thrown upon the obscure subject of terrestrial magnetism. It is true, the nature of the relation between the magnetic and geological phenomena is not so easily determined; but it seems to become certain that the internal structure of the earth's crust has an important influence upon terrestrial magnetism, even if it be not in any degree its first cause. Terrestrial magnetism and its changes have sometimes been considered explainable by solar influences alone, no longer by direct action of the sun as a magnet, but by the sun's heating the atmosphere or the earth's crust. The present phenomena seem, however, to point to more strictly terrestrial processes as the true cause, and to suggest that the solar influence may partly at least be exerted through the attraction of gravitation as well as through heat. The enormous and locally unequal strains produced by the contraction of the earth's crust in cooling would be particularly liable to be affected by the presence of a deep fault or by a sharp anticlinal. Such lines would be places where the crust has yielded and is readier to yield, and consequently where the strain has

"Ancient Britons Hunting the Megaceros."

"Ancient Britons Hunting the Megaceros."

Engraved by Sidney Sherb[illegible] and by permission of Messrs. Sotheby & Co. from a Drawing by J. C. Millais.



The two great Stags of Warnham Court.

Drawn by J. G. Millais. Reproduced by permission of Messrs. Sotheran & Co. from "British Deer and their Horns," by J. G. Millais.

been to some extent relieved and is less. The recent occurrence of earthquakes along the New Jersey end of this very fault-line shows that the resistance there is less, and that the remaining strain must likewise be less. On such a comparatively weak yielding line the rock beds in readjusting themselves, even where there is no violent earthquake, must occasion a certain amount, not only of strain, but of friction and heat that might give rise to electrical currents. A decided magnetic effect, too, has sometimes been observed to accompany earthquakes, and in some cases to precede them. In like manner, the strains and yielding or readjustment that may be occasioned by the attraction of the sun and moon might apparently cause electrical currents; and, in fact, magnetic disturbances have been found to correspond, like tides, with the place of those heavenly bodies. Again, the broken or arched form of the rock beds may permit at least a temporary local variation in the temperature of the crust, as affected by the earth's hot interior, that could occasion electrical earth currents. Terrestrial magnetism seems, then, to arise not only from the manifold action of the sun's heat upon the air and the earth's crust, but from the internal movements of the crust and from the tidal effect of the sun and moon upon the air, ocean, and solid earth.

The author does not admit that the magnetic curves could have been produced by any known deposits of iron-ore or trap, near or distant; comparing such an idea to the ancient Oriental tales of the loadstone that drew men's boot-nails, or the seaside mountain that pulled the bolts out of ships' sides. He adds:—"Deposits of magnetic iron-ore, though differing much in magnetic force, seldom directly affect the most delicate magnetic needle at a distance of more than a few hundred feet."

REVIEWS.

British Deer and their Horns. By John Guille Millais, F.Z.S., etc. With 185 text and full-page illustrations, mostly by the Author, assisted by Sidney Steel, two by E. Roe, and photographs; and a series of unpublished sketches by Sir Edwin Landseer. Imp. 4to; pp. xviii and 224. (London: Henry Sotheran & Co., 37, Piccadilly, and 140, Strand, W.C. 1897.)

(PLATES III AND IV.)

MR. MILLAIS is already favourably known to the public as the author of "Game-Birds and Shooting Sketches" and "A Breath from the Veldt," both rich in illustrations. Although a thorough sportsman, and, like his father, the late Sir John Everett Millais, Bart., R.A., a born artist, Mr. John Guille Millais combines with these qualities sufficient of the true naturalist and palæozoologist, to lead him in his "History of British Deer and their Horns" to enter upon a brief account of the ancient types of deer which inhabited these Islands in prehistoric times,

The two great Stags of Warnham Court.
Drawn by J. G. Millais. Reproduced by permission of Messrs. Sotheran & Co. from "British Deer and their Horns," by J. G. Millais.

and whose skeletons and antlers preserved in the British Museum (Natural History), Cromwell Road, or in other kindred institutions, now form their only record. Many of these Mr. Millais has sketched with commendable fidelity. It is difficult to separate the extinct *Alces latifrons*, found in the Cromer Forest Bed and at Happisburgh and Corton, and on the Dogger Bank, from the living elk (*Alces machlis*) found subfossil at Cleveland, Yorkshire, and in about thirty-one English, Scotch, and Irish localities, and which still survives in Norway and in Canada.

To the same northern category also belongs the reindeer (*Rangifer tarandus*), which is recorded from more than eighty localities in this country, is still living in Northern Europe, Asia, and America, and is believed to have survived in Caithness until the middle of the twelfth century. Of fossil varieties of the true deer, *Cervus polignacus*, *C. Brownii*, and *C. Savini*, little need be said. They are forms closely related to the existing fallow-deer (*C. dama*). *Cervus Dawkinsii* and *C. Fitchii* are most probably related to the elk (*Alces machlis*); *C. verticornis*, *C. tetraceros*, and *C. Sedgwickii* are all from the Norfolk Forest Bed at Cromer, Bacton, and Kessingland. *C. tetraceros* has the beam more or less straight, with the tines rounded, simple, and springing all from one side of the beam. *C. Sedgwickii* has the beam flattened and more arched, and the tines, although upon the same plane, are flattened and branched.

There is yet another extinct deer (the *Cervus giganteus*), the largest of all the Cervidæ, whose remains have been obtained not only in great abundance, but in so perfect a state, in Ireland that entire skeletons are to be seen in many of our Museums, whilst the antlered skulls adorn many noble residences in England, Scotland, and Ireland. Formerly known as "*Megaceros Hibernicus*" or as "the gigantic Irish elk," yet it is in no wise related to the elk, although frequently spoken of as such. It is in every respect a true deer, and in many of its characters (save that of size) not unlike our existing fallow-deer.

When it is stated that these deer frequently measure 9 feet across the antlers, the weight of which is as much as from 80 to 90 lbs., one is astonished at the amount of vital energy in such a beast as would enable it to throw out year after year such a mass of osseous matter in the short period of four months, for the horn-growth of the *Megaceros* doubtless followed the same rules as those which govern the horn-growth of other deer to-day.

"In the British Isles this deer seems to have been most numerous in Ireland, where remains are found below all the peat-bogs in the lacustrine shell-marl. In County Limerick the greatest number of heads has been dug up, notably in the extinct Lake of Loch Gur, where literally hundreds of them have been unearthed. In 1875, Mr. R. J. Moss made excavations in the bog of Ballybethag, 9 miles south-east of Dublin, and during the summers of 1876–77 twenty-six heads and three complete skeletons were procured. Below the great bog, in the vicinity of Tullamore, is another

productive district, as is also the margin of Loch Derg (Co. Galway) and Killowen (Co. Wexford).

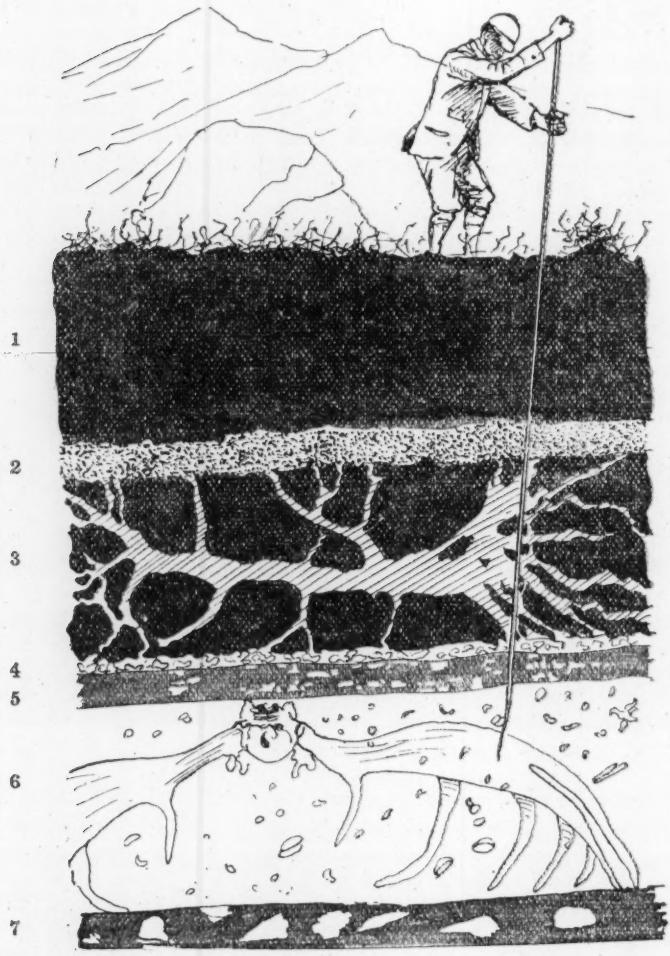
"The first tolerably perfect skeleton of *Megaceros* was found in the Isle of Man, and was presented by the Duke of Athole to the Edinburgh Museum in 1820."[1] In 1896 a second, nearly perfect, example of *Megaceros* was obtained near Poortown in the same island. (See p. 116.)

In England the remains of this great deer are rare. The first skull and antlers were dug out of the peat-moss at Crowthorpe in Yorkshire. About twenty-nine localities are recorded, but the remains are exceedingly fragmentary. In France its remains are said to have been found near the foot of the Pyrenees; in the valley of the Oise it has been found associated with the mammoth, the rhinoceros, the musk-ox, the reindeer, and hippopotamus. There is one skull with imperfect antlers in the British Museum from as far east as the Government of Orbowschen, in Russia. Complete heads and antlers have recently been found in the south-west of Scotland.

There is good evidence for the conclusion that after the great deer had spread into Ireland, and probably long before its extinction in this country or in Western Europe, Ireland must have become isolated from England, and during a long succeeding period the *Cervus giganteus* lived and flourished in that island, and was neither exterminated there by prehistoric man nor by any of the Carnivora, but by a great and gradual change which took place in the climate of that country. This change, in which Scotland and a part at least of England also partook, was an increase in cold and a settled humidity of climate, tending to a great growth of peat, which in time filled up the former extensive fresh-water lakes, once so abundant, and injuriously affected the forest growth over large areas of the country. With this change the great Irish deer died out; but its remains show that it was living there before the growth of *Sphagnum* or bog-moss had taken place, for they rest in the shell-marl beneath the peat. This shell-marl is really composed of the accumulated deposit of dead and decomposed shells of fresh-water *Unio*, *Anodon*, and *Limnæa*, so that it represents a long and tranquil period of time during which conditions were favourable to forest growth, and consequently to the deer and the other denizens of the woods and waters.

We give a diagram-sketch by Mr. Millais of the way the Irish deer occurs beneath the peat (see Woodcut). The man who searches for the megaceros-heads uses a rod about 25 feet in length. First of all he takes a survey of the bog, and from long experience knows where to commence his probing in what seems a likely spot. Should the iron strike stone or gravel, he knows by the gritty feel, whilst horn gives a dull thud, and by turning the rod round and round the searcher is able to tell of what nature is the substance he has struck.

[1] This skeleton from the Isle of Man was described by Baron Cuvier in his "Ossemens Fossiles," tome iv, pl. viii, fig. 1.



HOW THEY HUNT THE IRISH DEER AT THE PRESENT DAY.

Showing mode of finding the heads, and the strata in which they are generally imbedded.

1. Peat (top layers), 3 feet.
2. Gravel, 6 inches.
3. Peat (lower layer with trees), 3 feet.
4. Layer of oak-leaves, 3 inches.
5. Blue clay (mixed with shells), 6 inches.
6. Lacustrine shell-marl (with remains of *Megaceros*, and fresh-water mollusca), 3 feet.
7. Blue clay, mixed with subangular stones.

(Thickness shown in diagram, about 12 feet. Many of the peat-bogs are *far thicker*.)

Many a time a day's digging only produces a head not worth lifting, owing to its being broken in many pieces, or perhaps it is only a dropped antler.

As to the causes which have led to the extirpation of the larger mammalia, we do not think it necessary to postulate a universal cause or agent of destruction before which all the big herbivora were swept away. Professor Owen long ago pointed out that the large mammals were always the first to suffer from floods or from droughts; events which happen most frequently within the tropics, but which may occur occasionally in almost any country.

Nor can we look at the accumulated results of subaerial and diluvial action, especially in such an extensive region as Argentina, without perceiving that æolian agencies—wind-storms, dust-storms, rain-storms, and floods—acting on the Sierras and higher plateaux for thousands of years, have led to the gradual accumulation of those vast masses of fine material which have built up the great Pampean formation, while along the course of the great alluvial valleys cut through its deposits by the rivers flowing from the north, lie buried many hundreds of giant Mylodons, Megatheria, and Glyptodons, once the denizens of the wooded region of Central South America.

The discovery of thousands of remains of great wingless birds in the superficial deposits of New Zealand has no connection whatever with the destruction of giant Edentates in South America, nor with giant deer in Ireland, save that man the destroyer was for a long period absent from the scene, and the *Dinornis* and its kindred enjoyed for many centuries undisturbed possession of their island-home, the *Harpagornis*, a large hawk, being the only bird of prey, and no Carnivora having reached New Zealand except seals.

With man came the hunter-element (see Plate III), and the "fire-stick"; and the forests, being not unfrequently accidentally lighted, the affrighted game (whether deer or Moas) fled towards the water to escape from the fire, and met their death by drowning in the morasses they attempted to ford.

In Australia the destruction of the large Marsupialia was probably not unfrequently caused by drought, which has so often proved fatal to the flocks and herds of the squatter in our own time. There, too, also local floods often prove, as in South America, most destructive, although of short duration, and these may even in a single night affect a vast area of country.

Mr. Millais has figured many fine antlers of Irish deer, notably those forming part of the complete skeleton of *Cervus giganteus* in Sir Edmund Loder's Museum at Leonardslee (pp. 4 and 9); and four heads on p. 19, from Loch Gur, from the Royal Dublin Society, from County Waterford, and from Limerick, which illustrate remarkable divergences in mode of growth. The antlers in these specimens have lost their original crescent-form and become too much flattened out. This may either have been caused when the antlers were softened from lying in the bog, or afterwards, when mounted, they have bent downwards by their own weight. Originally they were certainly more V-shaped. On pp. 14 and 15 are given

two views of a splendid head and antlers from near Tullamore, Ireland, in the possession of the Duke of Westminster, in which the palms are enormously developed.

There are remains of 19 individuals in the British Museum, comprising 4 complete skeletons, 3 antlered males and 1 of a (hornless) female; 2 skulls of hinds from Naull, Co. Dublin; 8 skulls with antlers which have no special locality save "Later Tertiary deposits, Ireland"; 1 head from Red Bog, Dunshaughton, Ireland; 1 skeleton from Axe Corey, Co. Wexford; 2 skulls of males with shed antlers from the Dogger Bank; and 1 head from Russia.

The remaining types of British Deer—the "Red-deer" (*Cervus elaphus*); the "Fallow-deer" (*Cervus dama*); and the "Roebuck" (*Capreolus caprea*)—are so well known in the living state, that they would appear to have little claim on the attention of the palæontologist. When, however, we study the Pleistocene deposits of our Island, we are led to find that even these denizens of our parks have a more or less remote geological history, not wholly devoid of interest.

Taking the red-deer as the typical representative of a great group of Cervidæ, which are spread over Europe, North Africa, Asia (north of the Himalayas), and North America, we find these are mainly characterized by the conformation of the antlers. In this type the brow- and bez-tine are both present; the beam is nearly cylindrical, subdividing into two or more points at the summit.

The group of allied species would include the red-deer (*Cervus elaphus*); the Canadian wapiti (*C. Canadensis*); *C. maral*; the Thian-shan deer (*C. eustephanus* or *C. Leudorfi*); the Amurland deer (*C. xanthopygus*); *C. corsicanus*; the Barbary deer (*C. barbarus*); and possibly also the Hangul or Cashmir deer (*C. Kashmirieusis*). Our brickearths, cave-deposits, and peat-bogs also yield evidence of deer-remains far larger in size than those now living, so that there can be little doubt that, ancestrally at any rate, the great red-deer and the wapiti were closely related.

In Flower & Lydekker's great work on Mammals, living and extinct, stress is laid on the absence of a cup at the surroyals, as distinguishing the wapiti from the red-deer; nevertheless, many red-deers' antlers have no trace of the cup whatever. Indeed, after studying a long series of them one cannot help feeling that the richly crowned antlers of certain red-deer from the peat, notably the pair obtained from the bed of the River Boyne at Drogheda, Ireland (part of the Egerton Collection), owe their unusual development to specially favourable environments and abundance of food, as exemplified in the collection of magnificently crowned heads preserved in the Castle of Moritzburg by H.M. the King of Saxony (sixty of the choicest of which have been figured by Dr. A. B. Meyer, Director of the Royal Zoological Museum in Dresden, in two volumes, royal folio, one vol. published in 1883 and one in 1887).

In Mr. Millais's work (p. 23) he writes: "The Warnham deer are second to none in this country in the matter of body and horn.

Their origin, however, is quite recent, and even after the introduction of the Stoke deer, by which the herd was strengthened some years ago, they were in no wise remarkable until the late Mr. F. M. Lucas took them in hand and began a series of experiments with a view to improving the pasture—about 250 acres in extent. Every alternate year he dressed the land with bone-dust, the effect of which soon made itself felt. The nutrimental qualities of the grass seemed to be improved 70 per cent., yielding exactly what was wanted for fattening and horn-growing. Half the park is reserved for hay, so the red-deer, which number about 100, have no great extent of ground to range over and very little winter-feeding. Nevertheless, they thrive and have continued to improve steadily since 1884, when the dressing was first tried, and at the present time a four-year-old Warnham stag is better than an adult animal in most other English parks." (See Pl. IV.)

Mr. Millais gives on p. x an illustration of a pair of antlers grown by a stag living on an open heather-covered mountain (Castlewellan, Ireland), with but little wood-shelter at the base. Two other heads on pp. 130–1, one from Braemore forest, Ross-shire, the other from Eskdale, and the pair of fossil antlers from Bakewell, Derbyshire (figured in Pl. II, Geol. Mag., Feb. 1898), may serve to illustrate the simpler form of red-deer antlers in which the cup and highly-branched crown are but little developed; the beam may be of great strength, but it and the tines are well-formed, symmetrical, and well-adapted for offence and defence. This type appears to be a mountain-dwelling, hardy, fighting stag. The crowned antlers with such a large number of points (often from thirty to forty) are found in the peat-deposits, and belonged to stags which must have been as well-fed in a natural state as are those in Mr. Charles Lucas's park at Warnham Court, or in the German deer-forest of the King of Saxony at Moritzburg. Clearly, in these latter instances, the excessive richness of the growth of antlers is a luxury which would only be found exceptionally in a wild state, and must require special care for its proper maintenance even in a park-herd (or under domestication).[1]

Passing over the fallow-deer as affording less geological interest, we come lastly to the little roebuck, *Capreolus caprea*, a small form of deer and a truly wild denizen of our woods, being found in Dorsetshire, Hampshire, and Essex, in the south, in the west in Wales, away north to Scotland, and widely over Europe and Western Asia. The male is somewhat over 2 feet in height at the withers, of a dark reddish-brown colour in summer, with a white patch on the rump. The small antlers stand close together at their base, have a short rugged beam, rising vertically, then bifurcating, the posterior branch again dividing. The roe-deer dates from the

[1] Mr. Lydekker, F.R.S., informs the writer that there is a magnificent series of red-deer antlers to be seen in the Hall of Hampton Court Palace, where they may have been since the days of its founder, the famous Cardinal Wolsey, in 1525, or since its rebuilding by Wren in 1690.

Pliocene period, and is doubtless related to several other small Cervidæ, some of which, like the Chinese water-deer, are hornless forms.

We must now part with Mr. Millais, but we do so with regret. We cannot imagine a more charming book for the Library table of a country house than his "British Deer and their Horns."

REPORTS AND PROCEEDINGS.

Geological Society of London.

January 19, 1898.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read :—

1. "On some Gravels of the Bagshot District." By Horace W. Monckton, Esq., F.L.S., F.G.S.

The author refers to his papers on Gravels South of the Thames published in the Quart. Journ. Geol. Soc. for 1892 (p. 29) and 1893 (p. 308), and gives some additional details.

He suggests that the occurrence of stones which have been very little rolled or waterworn in gravels at certain localities affords evidence of the presence of ice in the water by which those gravels were deposited, and that the position of some sarsens which he describes is due to the same agency.

He gives details and exhibits photographs of a number of sarsens which he has seen *in sitû*.

2. "On the Occurrence of Chloritoid in Kincardineshire." By George Barrow, Esq., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

The rock containing the chloritoid was first found *in sitû* at the entrance to the little gully at the head of Friar Glen Burn, near Drumtochty Castle. It has since been observed at many places along a belt of country extending from the coast north of Stonehaven nearly as far as the North Esk.

The rock is easily recognized by the presence of numerous white spots, which are always present and are larger than the chloritoid. The chloritoid and the spots vary in size, being largest when the rock is most crystalline (a schist), and smallest when it is least crystalline (a slate). The mineral appears as minute glistening scales in the schist, but in the slate it can be recognized only with the aid of the microscope.

The optical characters are described, and shown to be identical with those of the mineral from the Île de Groix, and with those of the ottrelite from Ottré and Serpont.

An account of the methods adopted to obtain a pure sample is given. Several analyses were made, and it was proved that as the purification increased the analyses approximated more and more closely to the analysis of the mineral from the Île de Groix.

The final result was as follows :—

SiO_2	26·00
Al_2O_3	40·05
FeO	19·50
Fe_2O_3	5·05
MgO	2·88
Loss on ignition	6·00
Total	99·48

The author discusses some of the published analyses, and suggests that many of the discrepancies may be due to impurities in the material analyzed.

CORRESPONDENCE.

THE AGE OF THE RAND BEDS.

SIR,—In the GEOLOGICAL MAGAZINE, 1897, p. 549, Mr. W. Gibson states that I have obtained fossils of doubtful Carboniferous age from a dolomite associated with the Gat's Rand Beds. I am not aware of having made such a statement, and it certainly does not occur in the paper alluded to ("The Occurrence of Dolomite in South Africa," Q.J.G.S., vol. L, p. 561). In fact, so far as I am aware, no fossils of any kind have hitherto been discovered in the Dolomite of this country.

DAVID DRAPER.

JOHANNESBURG, *Dec.* 31, 1897.

THE OCCURRENCE OF *PLACOPARIA* IN THE SKIDDAW SLATES.

SIR,—In the course of my work on the Graptolite Fauna of the Skiddaw Slates I have come across two specimens of the trilobite *Placoparia*. No mention of this form is made by Postlethwaite and Goodchild in their paper on the "Trilobites of the Skiddaw Slates" (Proc. Geol. Assoc., vol. ix, p. 455), and as it is known to be characteristic of a definite horizon in other localities, it seems worth while to place on record the occurrence of this genus in the Lake District. The specimens in question come from two different localities, Outerside and Ellergill, and are in the Woodwardian Museum. The Ellergill specimen is a recent gift from Professor H. A. Nicholson.

GERTRUDE L. ELLES.

WOODWARDIAN MUSEUM, CAMBRIDGE, *February*, 1898.

OBITUARY.

OSCAR FRIEDRICH VON FRAAS.

BORN JANUARY 17, 1824. DIED NOVEMBER 22, 1897.

WE regret to announce the death of the veteran geologist Dr. Oscar von Fraas, of Stuttgart, Director of the Royal Würtemberg Museum of Natural History. He was born at Lorch, in Swabia, in 1824, and after his ordinary education at school he proceeded to the University of Tübingen. There he devoted special attention to

theology, with the intention of entering the Church; but he was at the same time also deeply interested in natural science, and he attended the lectures of Quenstedt, who filled him with enthusiasm for geology and palæontology. He worked hard in collecting fossils and making geological observations in Swabia, and when he had the opportunity of spending a year in Paris, in 1847, he attended the lectures of D'Orbigny and Elie de Beaumont at the School of Mines. On returning to his native country, Fraas followed his theological profession, and from 1850 to 1854 he was pastor of Laufen a. d. Eyach. In 1854 he became Conservator of the Department of Mineralogy and Palæontology in the Royal Würtemberg Museum at Stuttgart, an office which he held until a few years ago, when, on the retirement of Dr. von Krauss, he succeeded to the Directorship, and left his son, Dr. Eberhard Fraas, in charge of the minerals and fossils. In the course of his official labours, Dr. Oscar von Fraas not only made the Stuttgart collection one of the finest in Europe, and enriched it with Swabian fossil batrachians, reptiles, and mammals, many of which are absolutely unique; he also published popular writings to interest the people in his work, and carried on a long series of researches, of which the results appear in more than sixty papers and memoirs. Most of these relate to the geology, fossils, and prehistoric archæology of Würtemberg; but some also recount his experiences in the East, which he visited in 1864–5, and again in 1875. He paid special attention to the geology of the Lebanon; and the scientific results of his journeys through Syria are collected in a small volume entitled "Aus dem Orient," which was published in two parts (1867 and 1878). Among his larger memoirs, those on the Miocene Mammalian Fauna of Steinheim (1870), and on the armoured reptile *Aetosaurus* from the Swabian Trias (1877), are especially important contributions to knowledge. Dr. Oscar von Fraas was elected a Foreign Correspondent of the Geological Society of London a few days before his death.

LIEUT.-COLONEL CHARLES COOPER-KING, F.G.S.

BORN FEBRUARY 4, 1843. DIED JANUARY 16, 1898.

CHARLES COOPER-KING, Lieut.-Colonel Royal Marine Artillery (retired), died at his residence, Kingsclear, Camberley, Surrey, on the 16th of January, 1898, aged nearly 55 years. The only son of Major U. H. King, R.M., Light Infantry, he was born at Plymouth. He was at school there until the end of 1859, passed into the Royal Marines as a Marine Cadet in January, 1860, second on the list, and joined H.M.S. "Excellent." He passed as a Second Lieutenant R.M. at the Royal Naval College, Portsmouth, first on the list (1862); and, recommended for the R.M. Artillery, he was gazetted at Fort Cumberland. In 1864, he was appointed to command the detachment of Marines on H.M.S. "Scylla" in the China seas and Japan. He was promoted to First Lieutenant in 1865; and rejoined headquarters (Eastney) in 1867. He passed (fourth) into the Staff College, July, 1868; and in August he

married Harriet, daughter of the late C. V. Garrett, of Southsea. Passing out of the Staff College, first on the list, and specially recommended, he went through the usual course of study and practice in regimental duties at Aldershot, and the long course of gunnery at Woolwich and Shoeburyness (1871). He was appointed Instructor of Tactics, Administration, and Law at the Royal Military College at Sandhurst, 1872; and was Professor of the same subjects 1878–1885. His promotion as Captain dates November, 1875, and Major by Brevet, 1879. He retired from the Service February, 1886; and devoted his time and energy as a military instructor or "coach," preparing subalterns of the Militia for commissions in the Army. He leaves two daughters and five sons; two of the latter are Lieutenants in the Army.

After the systematic study of geology and chemistry was eliminated from the curriculum at the Staff College, and the professorships thereof had ceased, Colonel C. Cooper-King succeeded Major Mitchell as Lecturer on Geology in 1886. Dealing also with such other branches of Natural Science as the officer-students could find time to study, his synopsis of these lectures on "Applied Science" embraced not only the land, but water (fresh and salt), air and weather, magnetism and electricity, as well as food and forage. Colonel Cooper-King drew a large class to geology, both in the lecture-room and the field; for, being a military expert himself, his explanations of the science in relation to military tactics and battlefields were well appreciated.

Whether on the blackboard or on paper, his apt and facile illustrations of geological conditions and natural-history facts were very acceptable to his students and his scientific friends. Always observant, and ready with pen and pencil, his notebooks were rich with reminiscences of places and people, visited or met with, at home and abroad. In spite of frequent illness, due to rheumatism and heart-failure, his energy spurred him to persist as a hard worker, whether in the study on literary matters, in the field as military correspondent, or in his class-room among military students. Many of his friends in the Army remember with pleasure, and often with gratitude, the advantages they received from his teaching, as private instructor or at college; and, indeed, he was always ready to help, both cadet and officer, with advice and solid information.

He was an Assistant-Examiner in Geology, Geography, and Physiography for the Science and Art Department (South Kensington) and the Civil Service Commission for twenty years.

As literary work, we may notice his books—"On Map and Plan Drawing," "History of Berkshire," "George Washington," "The British Army," and "The Story of the British Army," the last-mentioned lately published. He was Editor of the "Great Campaigns in Europe," and for some time of "The United Service Magazine." Reviews, notices, and miscellaneous pieces by C. Cooper-King are scattered in different periodicals.

In his "History of Berkshire" (E. Stock, London, 1887), a good